NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

February 22, 2005

Flight Data Recorder - 10

Group Chairman's Factual Report
By R. Gregory Smith

A. EVENT

Location:	Jefferson City, MO
Date:	October 14, 2004, 10:15 CDT
Aircraft:	CL-600-2B19, N8396A
Operator:	Pinnacle Airlines, Flight 3701
NTSB Number:	DCA05MA003

B. GROUP

A group was convened on October 18-20, 2004.

Chairman:	R. Gregory Smith Aerospace Engineer National Transportation Safety Board
Member:	Samy N. Nasry Chief Technical Integrator Bombardier Aerospace
Member:	Bob Perkins Performance Engineer General Electric
Member:	Eric Kavicky Chief Engineer Pinnacle Airlines
Member:	Joseph M. Bracken Senior Staff Engineer Air Line Pilots Association
Member:	Katie Rudd Staff Engineer Air Line Pilots Association
Member:	T. R. Proven Air Safety Investigator Federal Aviation Information

C. SUMMARY

On October 14, 2004, at about 2215 central daylight time (CDT), N8396A, a Bombardier CL-600-2B19 operating as Pinnacle Airlines flight 3701 (d.b.a. Northwest Airlink) crashed in a residential area in Jefferson City, Missouri, about 2.5 miles south of the Jefferson City, Missouri, airport (JEF). The airplane was destroyed by the impact forces and a post crash fire. The two crew members were fatally injured. The flight was a repositioning flight from Little Rock, Arkansas (LIT) to Minneapolis-St. Paul, Minnesota (MSP). There were no passengers on board. There were no injuries on the ground.

D. DETAILS OF INVESTIGATION

On October 15, 2004, the Safety Board's Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: **L-3 Communications Fairchild Model F1000, 128 Word**
Recorder Serial Number: **01094**

The recorder was in good condition and the data were extracted normally from the recorder.

Recorder Description

This model FDR records airplane flight information in a digital format using solid-state flash memory as the recording medium. The F1000 can receive data in the ARINC 573/717/747/542a configurations and can record a minimum of 25 hours of flight data. It is configured to record 128 12-bit words of digital information every second. Each grouping of 128 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 128-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The F1000 is designed to meet the crash-survivability requirements of TSO–C124.

FDR Carriage Requirements

Federal regulations regarding the carriage requirements of FDRs on aircraft can be found in the following regulations: 14 CFR 121.343, 14 CFR 121.344, 14 CFR 121.344a and 14 CFR 135.152. In general, for turbine-powered transport category aircraft manufactured on or before October 11, 1991, an FDR must be installed on board that records a minimum of 18 parameters, and for those turbine-powered aircraft that seat between 10 and 19 passengers, the minimum is 22 parameters. Newly manufactured aircraft are required to be equipped with an FDR that records a minimum of 88 parameters. Specifically, the accident aircraft, N8396A, was operating such that it was required to be equipped with an FDR that recorded 34 parameters, as cited in 14 CFR 121.344. The accident aircraft was not in compliance with the Federal FDR carriage requirements. Specifically, the source of the vertical acceleration parameter is not updated at a rate that meets the recording intervals required by 14 CFR 121 Appendix M. Additionally the pitch attitude is recorded at a higher sample rate that the source is updated. In May 2003 the Safety Board issued Safety Recommendation A-03-15 to the

FAA addressing these issues. The aircraft manufacturer is aware of these problems and will be correcting them in the next update of the Data Concentrator Unit (DCU), which has not yet been scheduled.

Recording Description

The FDR recording contained approximately 51 hours of data. Timing of the FDR data is to the nearest second and referred to as FDR subframe reference number (SRN[1]). The accident flight was the last flight of the recording and its duration was approximately 55 minutes. During the accident flight, power was lost to the FDR resulting in a data dropout of approximately 3 minutes and 57 seconds based on the recorded GMT parameters. The dropout was filled with null data so that timing between pre-dropout and post-dropout events could be established with plots of the data.

The last four subframes (seconds) of data before the dropout, 02:55:16Z - 02:55:19Z have some parameters that are invalid, while other parameters appear to be valid. Data for this time frame should be treated as suspect because various onboard systems where switching power busses as the engines shutdown and power was subsequently lost. Similarly, after the dropout the data is also suspect from 02:59:16Z to 02:59:21Z as various systems came back online and re-initialized after APU start. After this time most of parameters appear to be valid, however some parameters associated with some aircraft systems appear to take a little longer to become valid again.

Time Correlation

Correlation of the FDR data from SRN to the accident UTC time was established with a pair offsets provided by the Aircraft Performance Specialist in the "Group Chairman's Aircraft Performance Study". There is one offset for the time period before the dropout and a second offset for the time period after the dropout. The accident flight data has been offset from SRN to UTC such that SRN 181300.6 equals 02:45:00Z for the pre-dropout data and SRN 182199.85 equals 03:00:00Z for the post-dropout data. In the plots that follow and the attached tabular listing this UTC time is referred to as "Computed UTC" to differentiate it from the GMT time recorded on the FDR.

Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention, of climbing right turns are positive (CRT=+)[2]. The parameters presented in this report decoded as expected.

Pressure Altitude

This FDR records the parameter "Altitude" as "Pressure Altitude," which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The "Pressure Altitude"

[1] Duration of FDR recording was measured in subframe reference number (SRN), where each SRN equals one elapsed second.

[2] CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, any parameter recorded that is indicating an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = +, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

information presented in the FDR plots and in the electronic data have not been corrected for the local altimeter setting at the time of the incident.

Parameter Table

Of the approximately 370 parameters available, the FDR group selected the parameters of interest for plotting based on the accident scenario. The table below lists the parameter name, how it is labeled on the plot, it's units, the parameter set(s) it is included in, and the plot number(s) on which it can be found.

Table 1 - Parameter Names, Abbreviations & Plot Numbers

Parameter Name	Plot Label (units)	Parameter Set(s)	Plot Number(s)
UTC Time[3]	Computed UTC (HH:MM:SS)	None	All (X-Axis)
Recorded GMT Time	GMT:Hours (hr) / GMT:Minutes (min) / GMT:Seconds (sec)	None	None, Tabular Data Only
Lateral Acceleration	Accel Lat (g)	1, 16	1, 14, 22, 32, 35
Longitudinal Acceleration	Accel Long (g)	1	1, 14, 22, 35
Vertical Acceleration	Accel Vert (g)	1, 15	1, 14, 22, 31, 35
Computed Airspeed	Airspeed Comp-L / -R(kts)	1, 12, 14, 15, 16, 17, 18, 9	1, 12, 14, 22, 30, 31, 32, 33, 34, 35, 38
Pressure Altitude	Altitude Press-L / -R (ft)	1, 12, 14, 15, 16, 17, 18, 9	1, 12, 14, 22, 30, 31, 32, 33, 34, 35, 38
Magnetic Heading	Heading Mag-L / -R (deg)	1, 16, 19	1, 14, 22, 32, 35, 38
Microphone Keying	Mic Key-L / -R (n/a)	1	1, 14, 22, 35
Stick Shaker	Stick Shaker-L / -R (n/a)	1, 3, 5, 14*, 15, 16, 17	1, 3, 5, 14, 16, 18, 22, 24, 26, 30*, 31, 32, 33, 35, 37
Aileron Position	Aileron-L / -R(deg)	2, 16, 19	2, 15, 23, 32, 36, 38
Control Wheel Position	Ctrl Whl Pos-L / -R (deg)	2, 16, 19	2, 15, 23, 32, 36, 38
Roll Attitude	Roll-L / -R (deg)	2, 16, 17, 19	2, 15, 23, 32, 33, 36, 38
Rudder Position	Rudder (deg)	2, 16, 19	2, 15, 23, 32, 36, 38

[3] UTC Time was determined by applying an offset to SRN based upon the correlation from the Aircraft Performance Specialist in the "Group Chairman's Aircraft Performance Study", as described above.

Parameter Name	Plot Label (units)	Parameter Set(s)	Plot Number(s)
Rudder Pedal Position	Rudder Pedal Pos (deg)	2, 16, 19	2, 15, 23, 32, 36, 38
Auto-Pilot Status	AP Status (n/a)	3, 5, 12, 14, 15, 16	3, 5, 12, 16, 18, 24, 26, 30, 31, 32, 37
Control Column Position	Ctrl Col Pos-L / -R (deg)	3, 14, 15	3, 16, 24, 30, 31, 37
Elevator Position	Elevator-L / -R (deg)	3, 14, 15	3, 16, 24, 30, 31, 37
Pitch Attitude	Pitch-L / -R (deg)	3, 14, 15, 19	3, 16, 24, 30, 31, 37, 38
Engine 10th Stage Bleed Air Valve Position	Eng1 / Eng2 Bld Air 10th ST (n/a)	4, 18	4, 17, 25, 34
Engine 14th Stage Bleed Air Valve Position	Eng1 / Eng2 Bld Air 14th ST (n/a)	4	4, 17, 25
Fuel Flow	Eng1 / Eng2 Fuel Flow (pph)	4, 17, 18	4, 17, 25, 33, 34
Engine N1 Speed	Eng1 / Eng2 N1 (%RPM)	4, 14, 17, 18	4, 17, 25, 30, 33, 34
Engine N2 Speed	Eng1 / Eng2 N2 Turb RPM (%RPM)	4, 17, 18	4, 17, 25, 33, 34
Engine Oil Pressure	Eng1 / Eng2 Oil Press (PSID)	4, 17, 18	4, 17, 25, 33, 34
Angle of Attack	AOA-L / -R (deg)	5, 14, 15, 17, 19**	5, 18, 26, 30, 31, 33, 38**
APU Bleed Air Valve Position	APU Bld Valve (n/a)	5, 18	5, 18, 26, 34
APU Fire Warning	APU Fire Warn (n/a)	5	5, 18, 26
APU Generator Status	APU Generator (n/a)	5, 9, 18	5, 9, 18, 26, 34
APU Overspeed Warning	APU Overspeed Warn (n/a)	5	5, 18, 26
APU Overtemp Warning	APU Overtemp Warn (n/a)	5	5, 18, 26
APU Ready Status	APU Ready (n/a)	5	5, 18, 26
APU DC Battery Direct Bus	DC APU Battery Direct Bus (n/a)	5	5, 18, 26
Stabilizer Position	Pitch Trim Stab Pos (deg)	5, 14	5, 18, 26, 30
Stick Pusher	Stick Pusher-L / -R (n/a)	5, 15, 16, 17	5, 18, 26, 31, 32, 33
Wind Direction (Magnetic)	Wind Dir (deg)	5	5, 18, 26
Windspeed	Windspeed (kts)	5	5, 18, 26
Cowl Anti-Ice Status	Anti-Ice Cowl-L / -R (n/a)	6	6, 19, 27
Engine Inter-Turbine Temperature	Eng1 / Eng2 ITT (degC)	6, 14, 17, 18	6, 19, 27, 30, 33, 34
Engine N1 Vibration	Eng1 / Eng2 N1 Vib (mils)	6	6, 19, 27
Engine N2 High Vibration	Eng1 / Eng2 N2 Hi Vib (n/a)	6	6, 19, 27

Parameter Name	Plot Label (units)	Parameter Set(s)	Plot Number(s)
Engine Oil Temperature	Eng1 / Eng2 Oil Temp (degC)	6	6, 19, 27
Ice Signal	Ice Signal-L (n/a)	6	6, 19, 27
APU Low Oil Pressure Caution	APU Oil Press Caut (n/a)	7	7, 20, 28
APU High Oil Temperature Caution	APU Oil Temp Caut (n/a)	7	7, 20, 28
Engine 10th Stage Bleed Air Duct Warning	Eng1 / Eng2 Bld Air 10th ST Duct Warn (n/a)	7	7, 20, 28
Engine 14th Stage Bleed Air Duct Warning	Eng1 / Eng2 Bld Air 14th ST Duct Warn (n/a)	7	7, 20, 28
Engine Fire Warning	Eng1 / Eng2 Fire Warn (n/a)	7	7, 20, 28
Engine Ignition	Eng1 / Eng2 Ignition A / B (n/a)	7, 14***, 17, 18	7, 20, 28, 30***, 33, 34
Engine Low Oil Pressure Warning	Eng1 / Eng2 Oil Press Warn (n/a)	7	7, 20, 28
Thrust Reverser Armed Advisory	Eng1 / Eng2 TR Arm Advisory (n/a)	7	7, 20, 28
Thrust Reverser Deployed	Eng1 / Eng2 TR Deploy (n/a)	7	7, 20, 28
Thrust Reverser Unlocked	Eng1 / Eng2 TR Unlocked (n/a)	7	7, 20, 28
Total Air temperature	Air_Temp:Total-L / -R (degC)	8, 18	8, 21, 29, 34
Radio Altitude	Altitude Radio-L / -R(ft)	8, 19	8, 21, 29, 38
EICAS Display Page	EICAS PED / SED Page (n/a)	8	8, 21, 29
Fuel Quantity	Fuel Qty Aux / Wing-L / Wing-R (lbs)	8	8, 21, 29
Groundspeed	Grdspd-L / -R(kts)	8, 19****	8, 21, 29, 38****
Master Warning	Master Warn (n/a)	8	8, 21, 29
Cabin Altitude Warning	Cabin Alt Warn (n/a)	9	9
Engine Jetpipe Overheat	Eng1 / Eng2 Jetpipe Overheat (n/a)	9	9
Low Hydraulic Pressure Caution	Hyd Press Low-1 / -2 / -3 Caut (n/a)	9	9
Hydralic Pressure	Hyd Press-1 / -2 / -3 (PSI)	9	9
Passenger Oxygen Caution	Passenger Oxy Caut (n/a)	9	9
Flap Lever Position	Flap Lvr Pos-0 / -20 / -30 / -45 Deg (n/a)	10	10
Flap Surface Position	Flap Surf Pos-L / -R (deg)	10	10
Flaps Failed	Flaps Fail (n/a)	10	10
Gear Disagree Warning	Gear Disagree Warn (n/a)	10	10
Gear Down and Locked	Gear Dnlock-L / -N / -R (n/a)	10	10
Gear Up and Locked	Gear Uplock-L / -N / -R (n/a)	10	10
Gear Weight-On-Wheels Caution	Gear WOW Input / Output Caut (n/a)	10	10

Parameter Name	Plot Label (units)	Parameter Set(s)	Plot Number(s)
Gear Weight-On-Wheels	Gear WOW-L / -N / -R (n/a)	10	10
Spoileron Position	Splrn Pos-L / -R (deg)	11	11
Spoiler Auto-Armed	Spoiler Auto Arm (n/a)	11	11
Spoiler Manual Control Armed	Spoiler Ctrl Man Arm (n/a)	11	11
Spoiler Manual Control Disarmed	Spoiler Ctrl Man Disarm (n/a)	11	11
Flight Spoiler Caution	Spoiler Flt Caut (n/a)	11	11
Flight Spoiler Position	Spoiler Flt-L / -R (deg)	11	11
Flight Spoiler Caution Each Side)	Spoiler Flt-L / -R Caut (n/a)	11	11
Ground Spoiler Caution	Spoiler Gnd-IB / -OB Caut (n/a)	11	11
Ground Spoiler Position	Spoiler Gnd-LIB / -LOB / -RIB / -ROB (n/a)	11	11
Spoileron Caution (Each Side)	Spoileron-L / -R Caut (n/a)	11	11
Spoileron Caution	Spoilerons Caut (n/a)	11	11
Spoileron Roll Caution	Spoilerons Roll Caut (n/a)	11	11
Auto-Pilot Altitude Hold Mode	AP Alt Hold Mode (n/a)	12	12
Auto-Pilot Altitude Preselect Captured	AP Alt Presel Cap Mode (n/a)	12, 14	12, 30
Auto-Pilot Altitude Preselect Mode	AP Alt Presel Mode (n/a)	12, 14	12, 30
Auto-Pilot Selected Altitude	AP Alt Sel (ft)	12, 14, 15, 16, 17	12, 30, 31, 32, 33
Auto-Pilot Climb/Descend Mode	AP Climb/Descend Mode (n/a)	12	12
Auto-Pilot Heading Select Mode	AP Hdg Sel Mode (n/a)	12	12
Auto-Pilot Navigation Mode	AP Nav Mode (n/a)	12	12
Auto-Pilot Pitch Mode	AP Pitch Mode (n/a)	12	12
Auto-Pilot Roll Mode	AP Roll Mode (n/a)	12	12
Auto-Pilot Vertical Speed Selected	AP Vert Spd (fpm)	12, 14	12, 30
Auto-Pilot Vertical Speed Mode	AP Vert Spd Mode (n/a)	12, 14	12, 30
AC Buses	AC Bus-1 / -2 (n/a)	13	13
AC Essential Bus	AC Essential Bus (n/a)	13	13
AC Service Bus	AC Service Bus (n/a)	13	13
AC Utility Bus	AC Util Bus-1 / -2 (n/a)	13	13
DC Battery Bus	DC Battery Bus (n/a)	13	13
DC Bus	DC Bus-1 / -2 (n/a)	13	13
DC Essential Bus	DC Essential Bus (n/a)	13	13

Parameter Name	Plot Label (units)	Parameter Set(s)	Plot Number(s)
DC Main Battery Direct Bus	DC Main Battery Direct Bus (n/a)	13	13
DC Service Bus	DC Service Bus (n/a)	13	13
DC Utility Bus	DC Util Bus-1 / -2 (n/a)	13	13
Emergency Power Only	Emer Pwr Only (n/a)	13	13
Emergency Bus	Emergency Bus (n/a)	13	13
Engine Generator	Eng1 / Eng2 Generator (n/a)	13	13
Notes: * Only Stick Shaker-R is displayed in Parameter Set 14, Plot 30. ** Only AOA-L is displayed in Parameter Set 19, Plot 38. *** Only Engine 1 Ignition A is displayed in Parameter Set 14, Plot 30. **** Only the Groundspeed-L is displayed in Parameter Set 19, Plot 38.			

Plots

The following plots, Plots 1 through 38, contain information describing the accident flight on October 14, 2004. The FDR Group identified several sets of parameters and several timeframes of interest for the accident flight. Each grouping of parameters is identified as a parameter set and annotated as such in the subtitle at the bottom of the plot along with text identifying the timeframe for the plot. All plots that are subtitled with the same set number include the same parameters, although the scaling of the parameters may be different depending on what scale is needed for a particular timeframe. All plots that are subtitled with the same timeframe cover exactly the same period of time and have the same time scale. The plotting convention used is that a trace showing data of the airplane going up or left is drawn going to the top of the page and data showing the airplane going down or right is drawn going to the bottom of the page.

The first group of plots, Plots 1 thru 13, contains the timeframe identified as the "Whole Flight" timeframe. These plots show an overview of parameter sets 1 thru 13 for the entire flight. Plots showing this timeframe include two magenta vertical lines marking the start and end of the data dropout. The parameter traces shown between these two vertical lines are artifacts of the plotting software, which automatically linearly interpolates between the last data point before the dropout and the first data point after the dropout. No FDR data was recorded for the time period between the dropout markers.

Plot 1 shows the data for parameter set 1, which includes: microphone keys; lateral, longitudinal, and vertical accelerations; stick shakers; magnetic heading; pressure altitude; and computed airspeed. The parameters for heading, airspeed, and altitude, are recorded separately from sources on the right and left side of the aircraft but combined into a single parameter each in this set for plotting purposes.

Plot 2 shows the data for parameter set 2, which are control inputs and surfaces that affect the yaw axis and bank angle of the aircraft. Parameters included in Set 2 are control wheel, aileron, rudder pedal, and rudder positions, and roll angle. Roll is recorded from separate sources on the left and right of the aircraft but combined into a single parameter for plotting in Set 2 plots.

Plot 3 shows the data from parameter set 3, which are control inputs and surfaces that affect the pitch angle of the aircraft. Parameters included in Set 3 are control column and elevator positions, stick shaker, auto-pilot (AP) status, and pitch angle. Pitch is recorded from separate sources on the left and right of the aircraft but combined into a single parameter for plotting in Set 3 plots.

Plot 4 shows the data from parameter set 4, which are some of the engine parameters recorded. Because two parameters are drawn in the same section of the plot, the traces are drawn in red and green to identify parameters from engine 1 and engine 2 respectively. Parameters included in Set 4 are N1, N2, oil pressure, fuel flow, and 10^{th} and 14^{th} stage bleed air valves.

Plot 5 shows the data from parameter set 5. Parameters included in Set 5 are stick shaker, stick pusher, AP status, stabilizer position, wind speed and direction, auxiliary power unit (APU) discrete parameters and angle of attack (AOA). AOA information is recorded separately from sources on both the left and right sides of the aircraft but is combined into a single parameter for plotting purposes in Set 5.

Plot 6 shows the data from parameter set 6, which are additional engine parameters and icing discretes. Parameters included in Set 6 are engine oil temperature, vibrations and high vibration discrete, inter-turbine temperature (ITT), engine overspeed warning, cowl anti-ice status, and ice signal discretes. Parameters from engine 1 or left sources are drawn in red and parameters from engine 2 or right sources are drawn in green.

Plot 7 shows the data from parameter set 7, which are discrete parameters from engines and the APU. Parameters included are engine bleed air 10^{th} and 14^{th} stage duct warnings, fire warnings, ignition status, oil pressure warnings, thrust reversers (TR) armed advisory, deployed and unlocked, and APU oil pressure and temperature cautions. . Parameters from engine 1 sources are drawn in red and parameters from engine 2 sources are drawn in green.

Plot 8 shows the data from parameter set 8. Parameters included in Set 8 are total air temperature, groundspeed, fuel quantities, EICAS pages selected, radio altitude, and master warning. Parameters from the left side and primary display are shown in red, parameters from the right side and secondary display are shown in green. The aircraft manufacturer provided information that the right groundspeed parameter is only functional when the aircraft has an optional second FMS installed. The accident aircraft did not have a second FMS.

Plot 9 shows the data from parameter set 9, which are hydraulics, and additional discrete paramters. The parameters included are hydraulic pressures, hydraulic system low pressure cautions, APU generator status, cabin altitude warning, passenger oxygen deployment, and engine jetpipe overheat warnings.

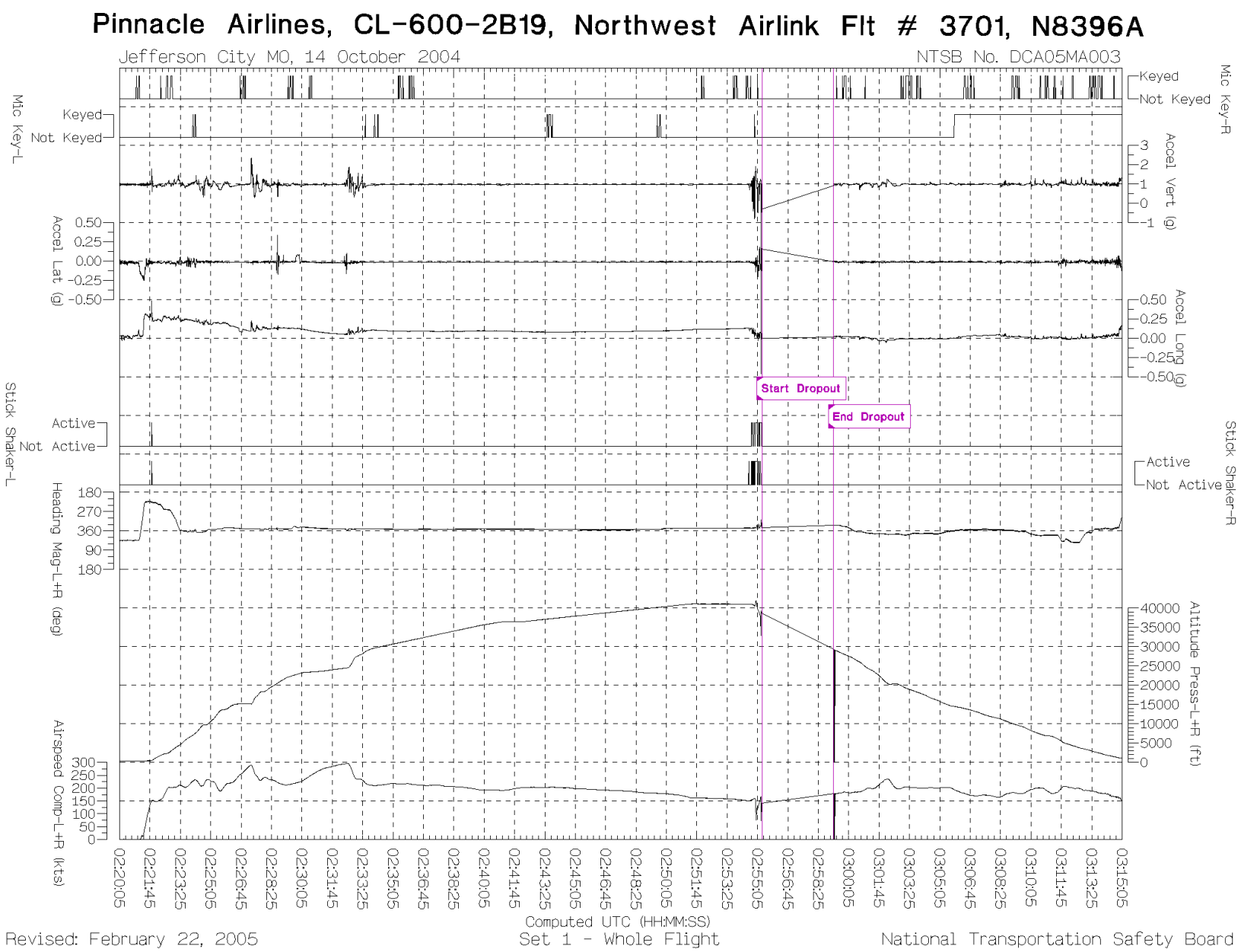
Plot 10 shows the data from parameter set 10, which are landing gear discretes and flap surface and handle positions. Parameters include in Set 10 are gear disagree warning, gear up and locked, down and locked, weight-on-wheels (WOW), WOW input and output cautions, flaps failed caution, left and right flap surface positions, and discrete

parameters indicating the position of the flap lever. Left and right flap surface positions are shown in red and green respectively.

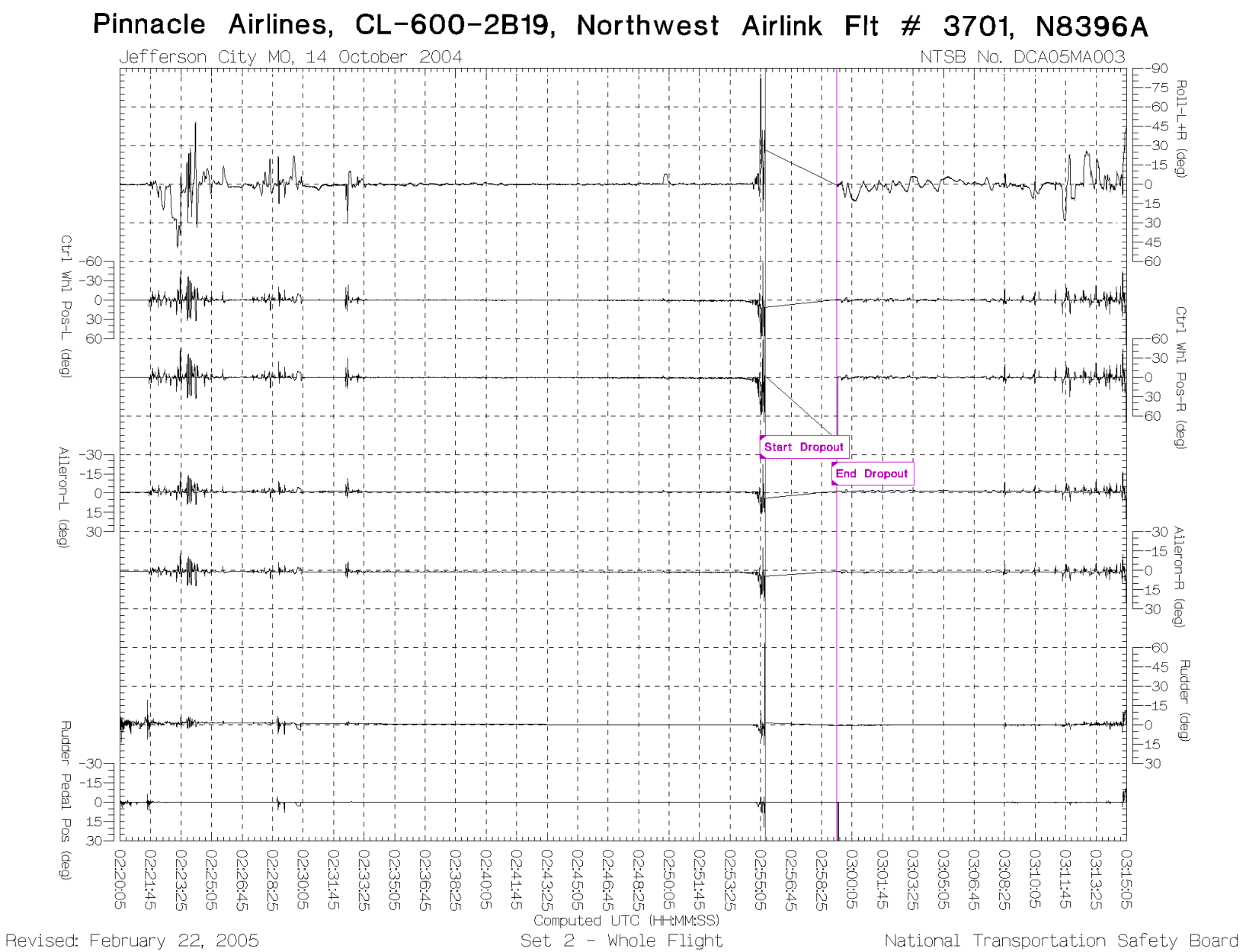
Plot 11 shows the data from parameter set 11, which are the spoiler and spoileron parameters. Parameters included in Set 11 are flight spoiler cautions, ground spoiler caution, ground spoiler positions, spoiler auto arm, spoiler control manual armed, spoiler control manual disarmed, left and right spoileron cautions, spoileron roll caution, spoileron caution, spoileron positions, and flight spoiler positions. Left and right spoileron positions are both drawn in the same section of the plot and are colored red for left and green for right. Left and right flight spoiler positions also use a common section of the plot and are colored red and green, respectively, as well.

Plot 12 shows the data from parameter set 12, which are the auto-pilot (AP) mode and status discrete parameters and basic flight parameters, and provides an overview of the auto-pilot use throughout the accident flight. Parameters included in Set 12 are AP status, altitude hold mode, altitude preselect mode, altitude preselect captured, vertical speed mode, climb/descend mode, pitch mode, heading select mode, roll mode, navigation mode, selected altitude, selected vertical speed, computed airspeed, and pressure altitude. The airspeed and altitude parameters are each recorded as two parameters from sources on the left and right side of the aircraft, but for plotting purposes they have been combined into a single parameter each in Set 12.

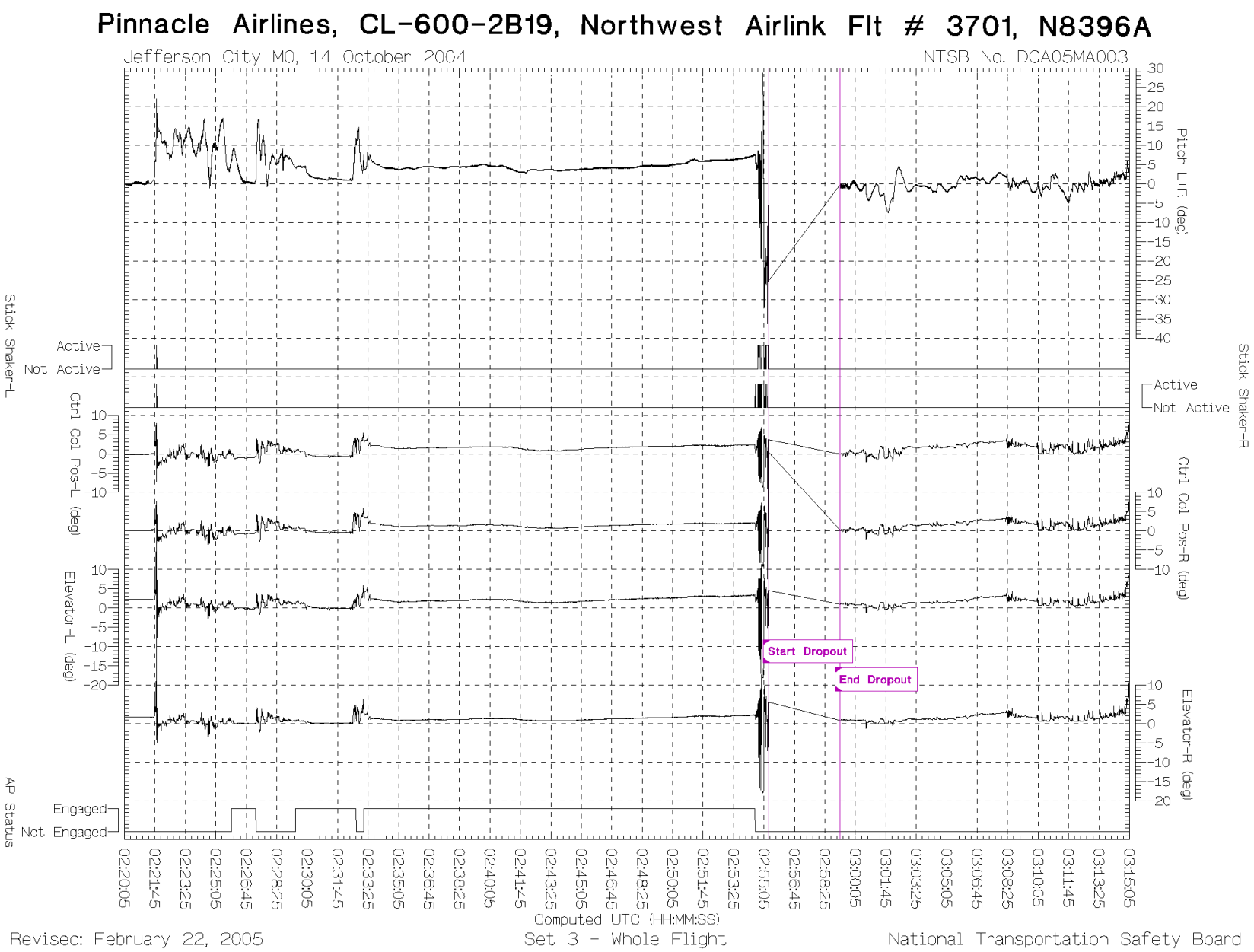
Plot 13 shows the data from parameter set 13, which are the electrical system discrete parameters, and provides an overview of the electrical system for the entire accident flight. Parameters included in Set 13 are AC busses 1 and 2, AC essential bus, AC service bus, AC utility busses 1 and 2, DC busses 1 and 2, DC utility busses 1 and 2, DC essential bus, DC service bus, emergency power only warning, emergency bus, DC battery bus, DC main battery direct bus, engine 1 and 2 generators, APU generator, and DC APU battery direct bus.



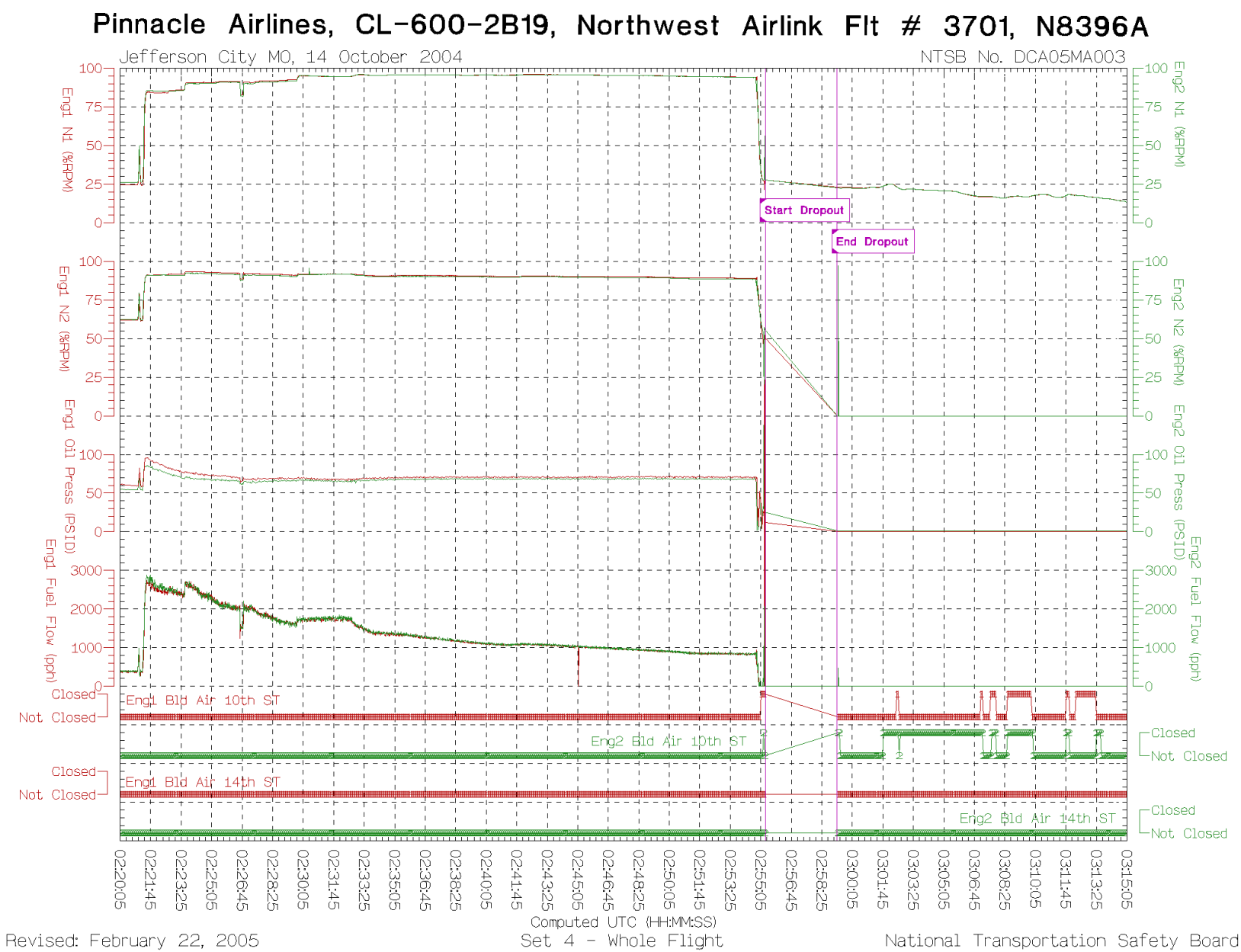
Factual Report Plot 1



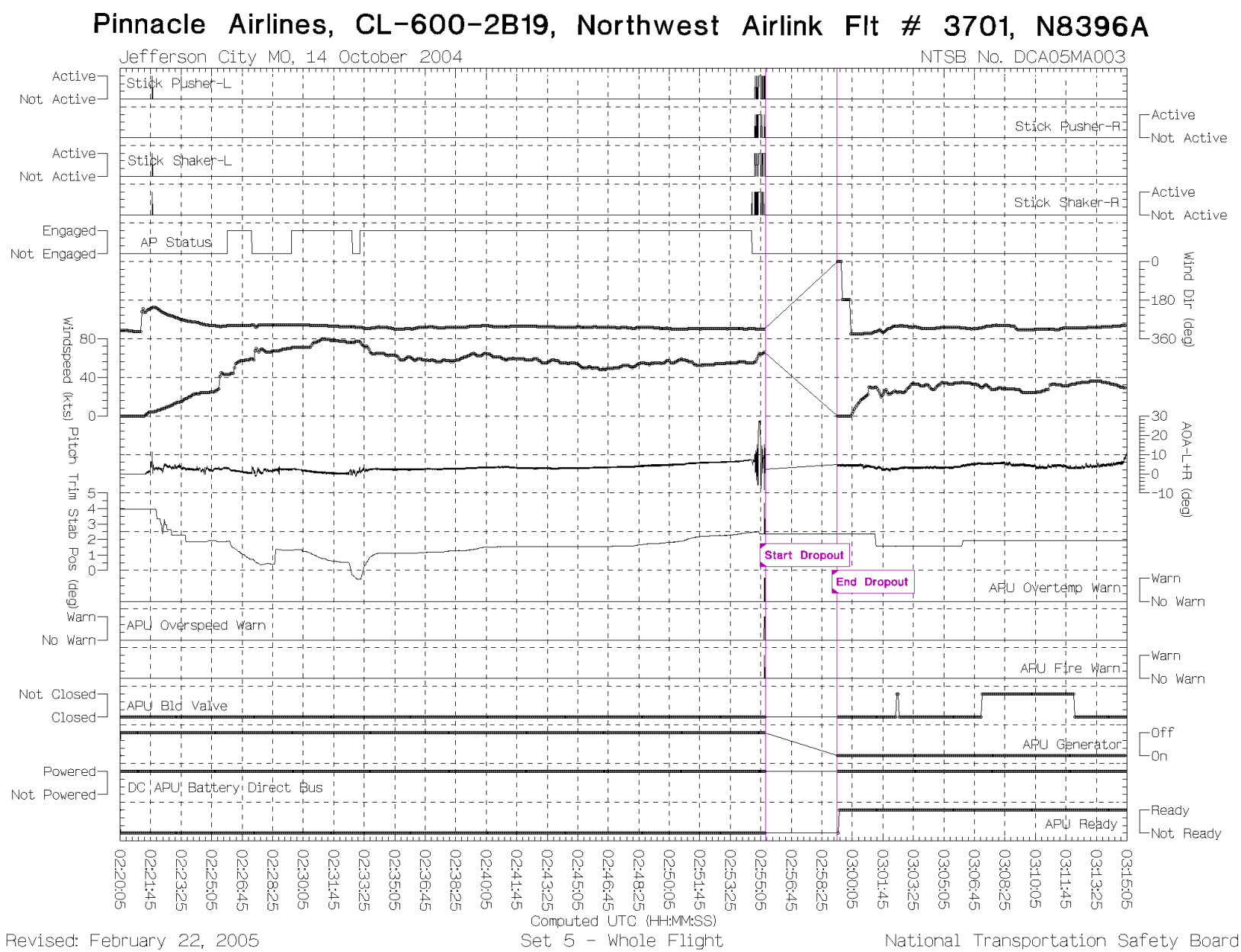
Factual Report Plot 2



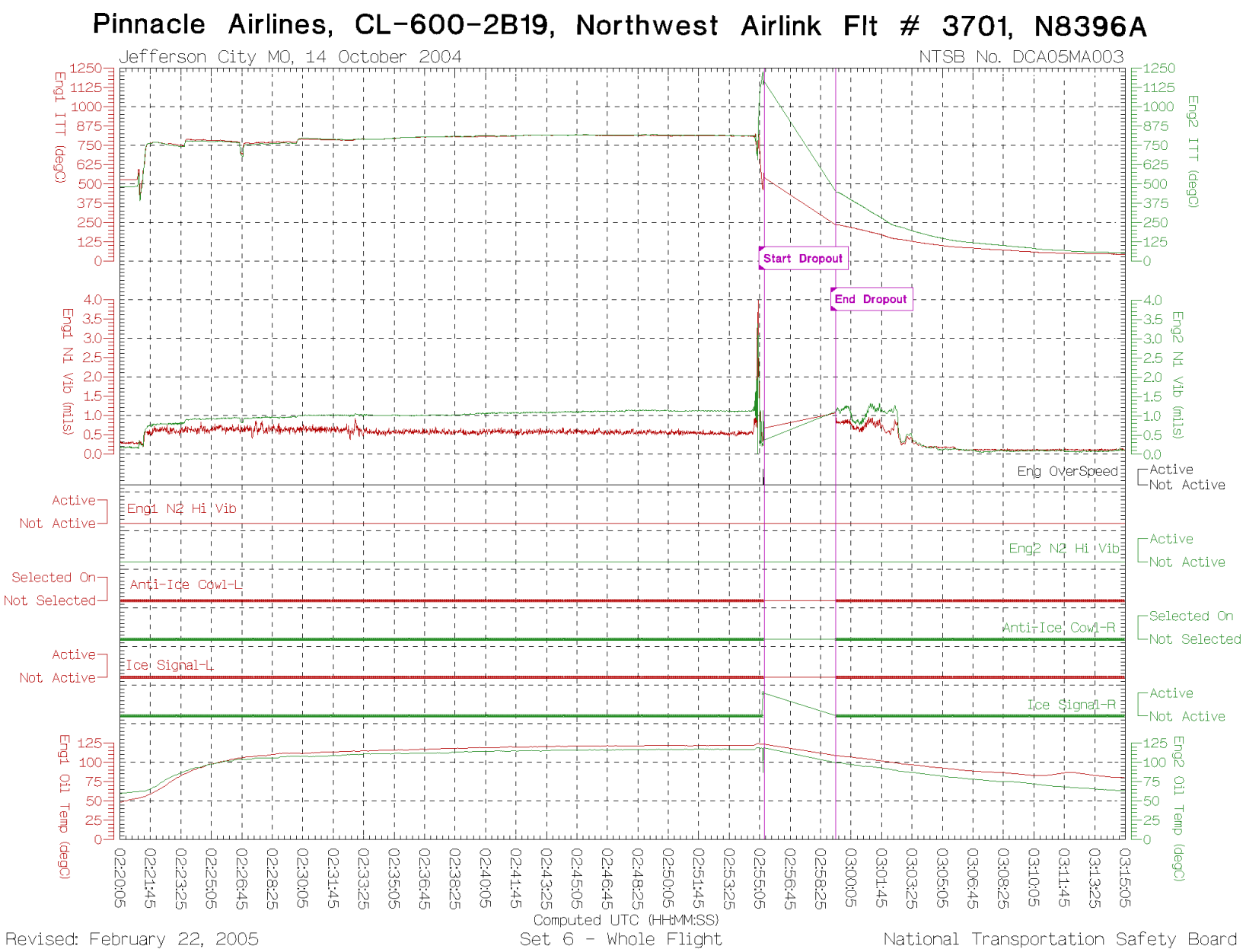
Factual Report Plot 3



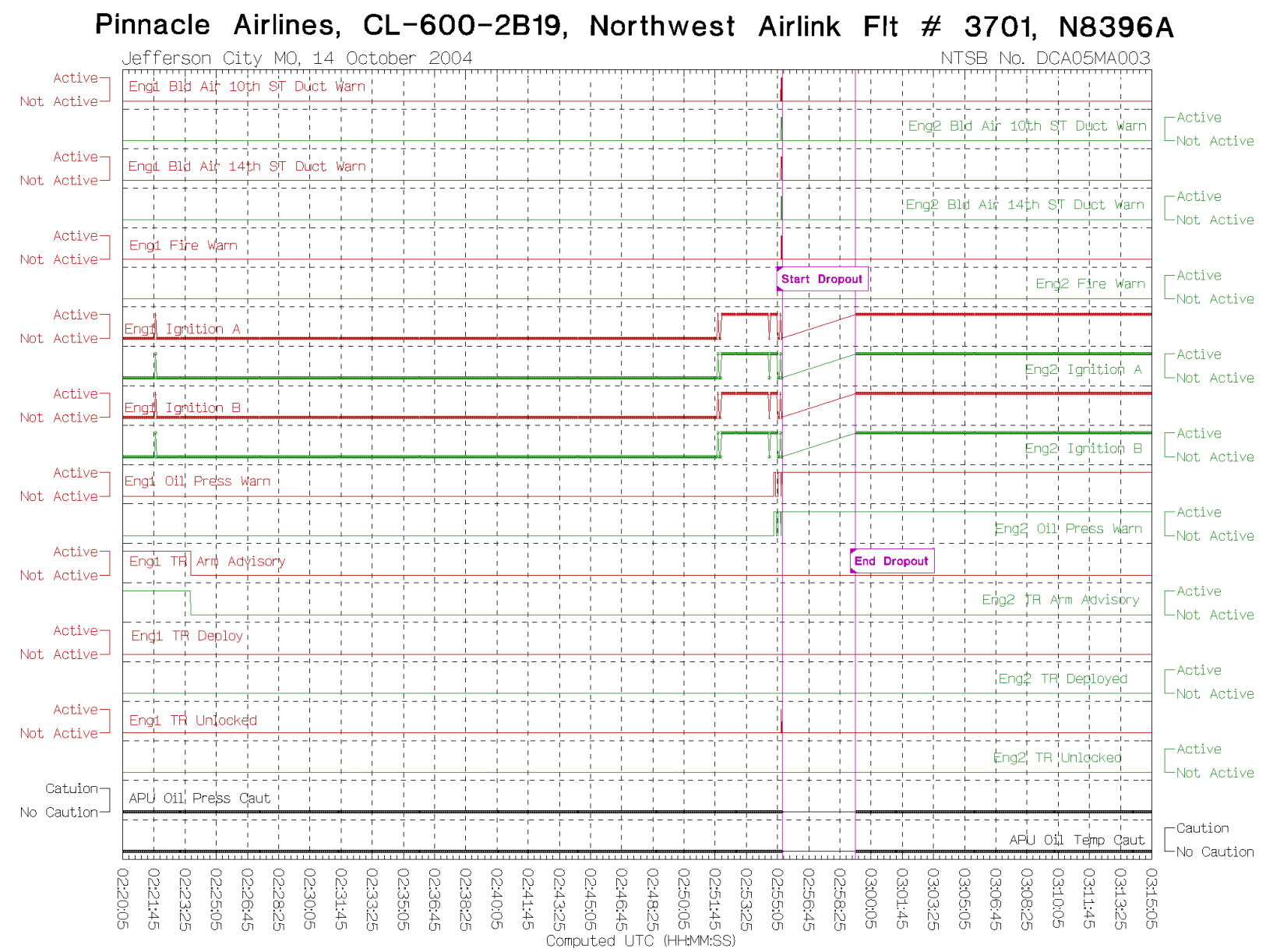
Factual Report Plot 4



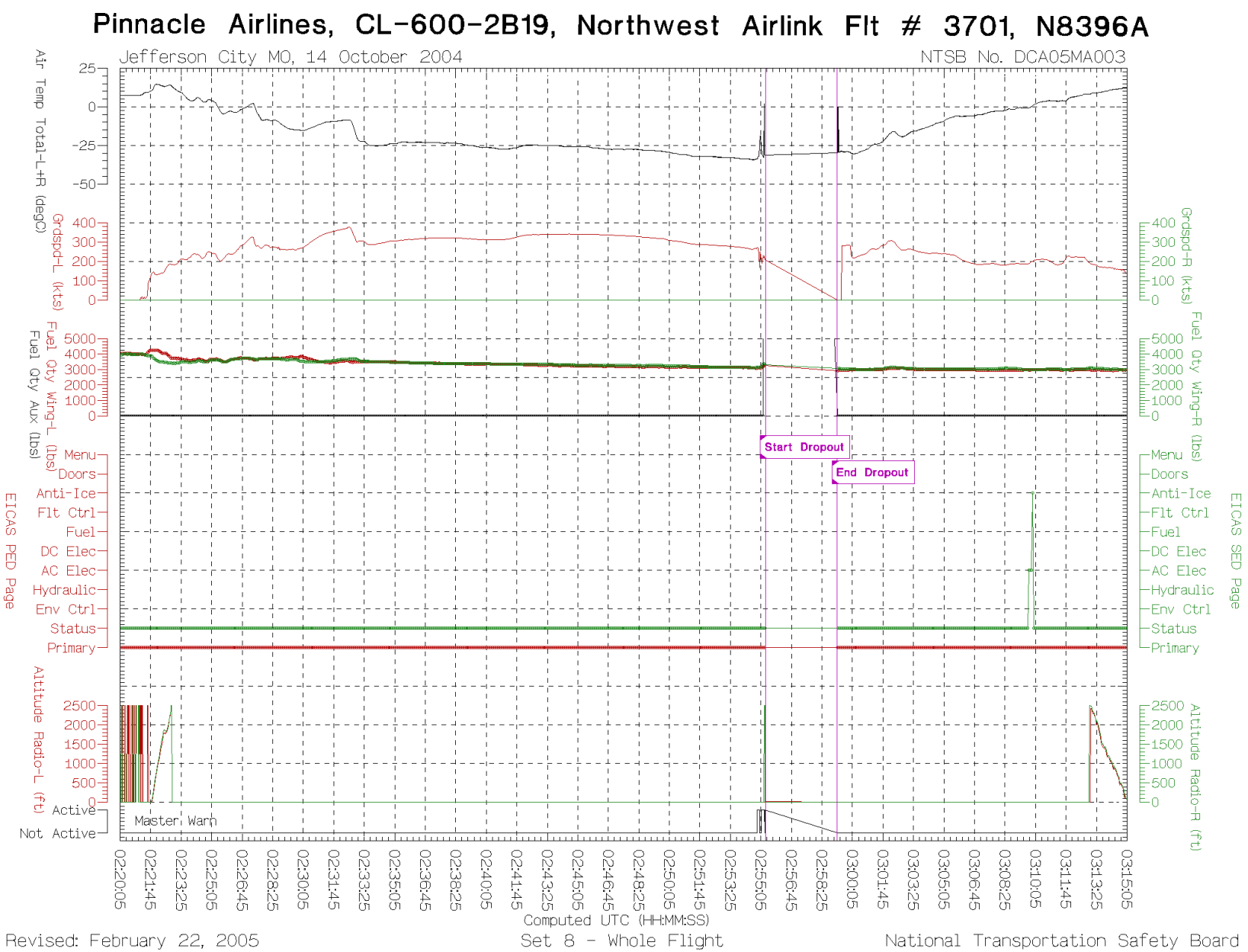
Factual Report Plot 5



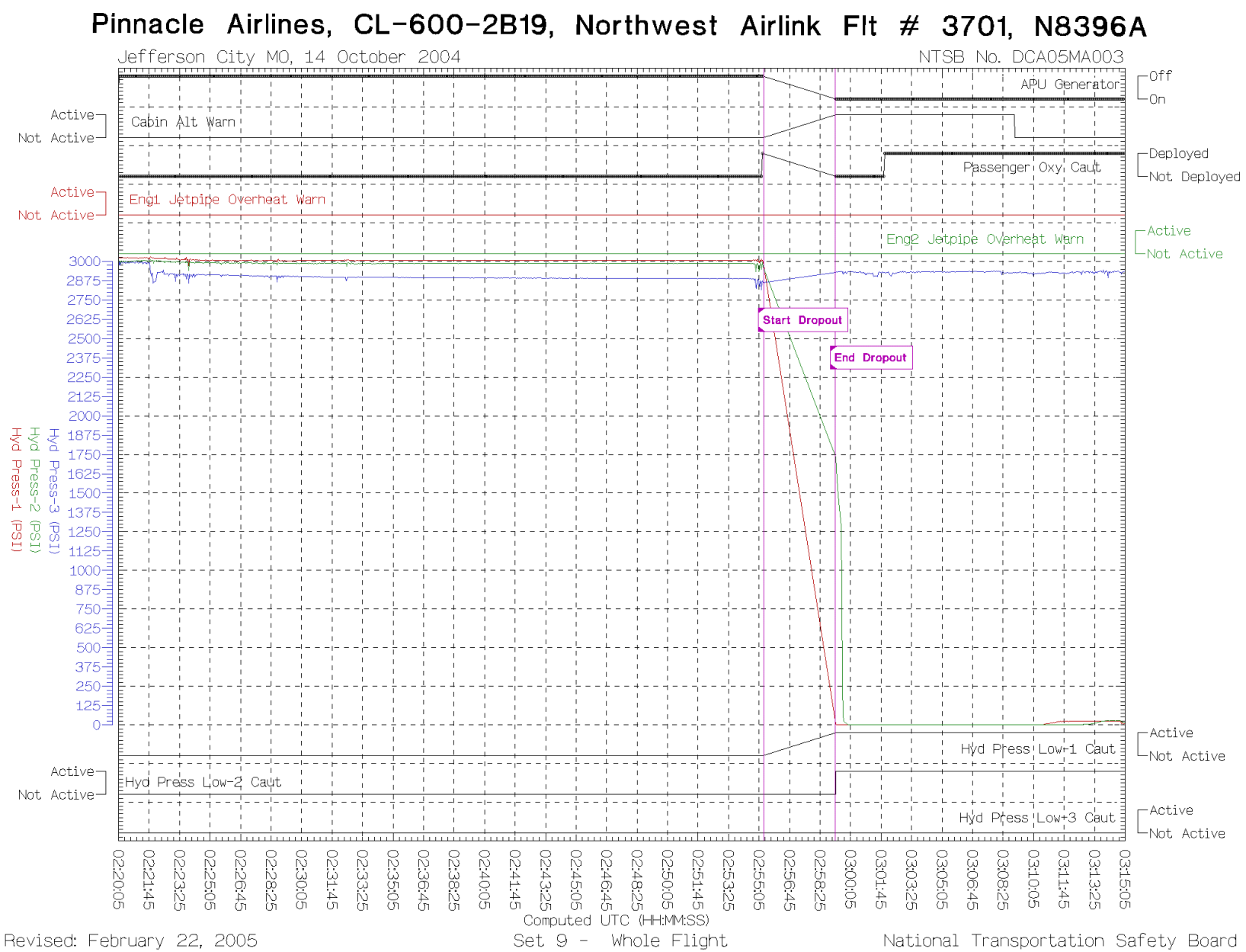
Factual Report Plot 6



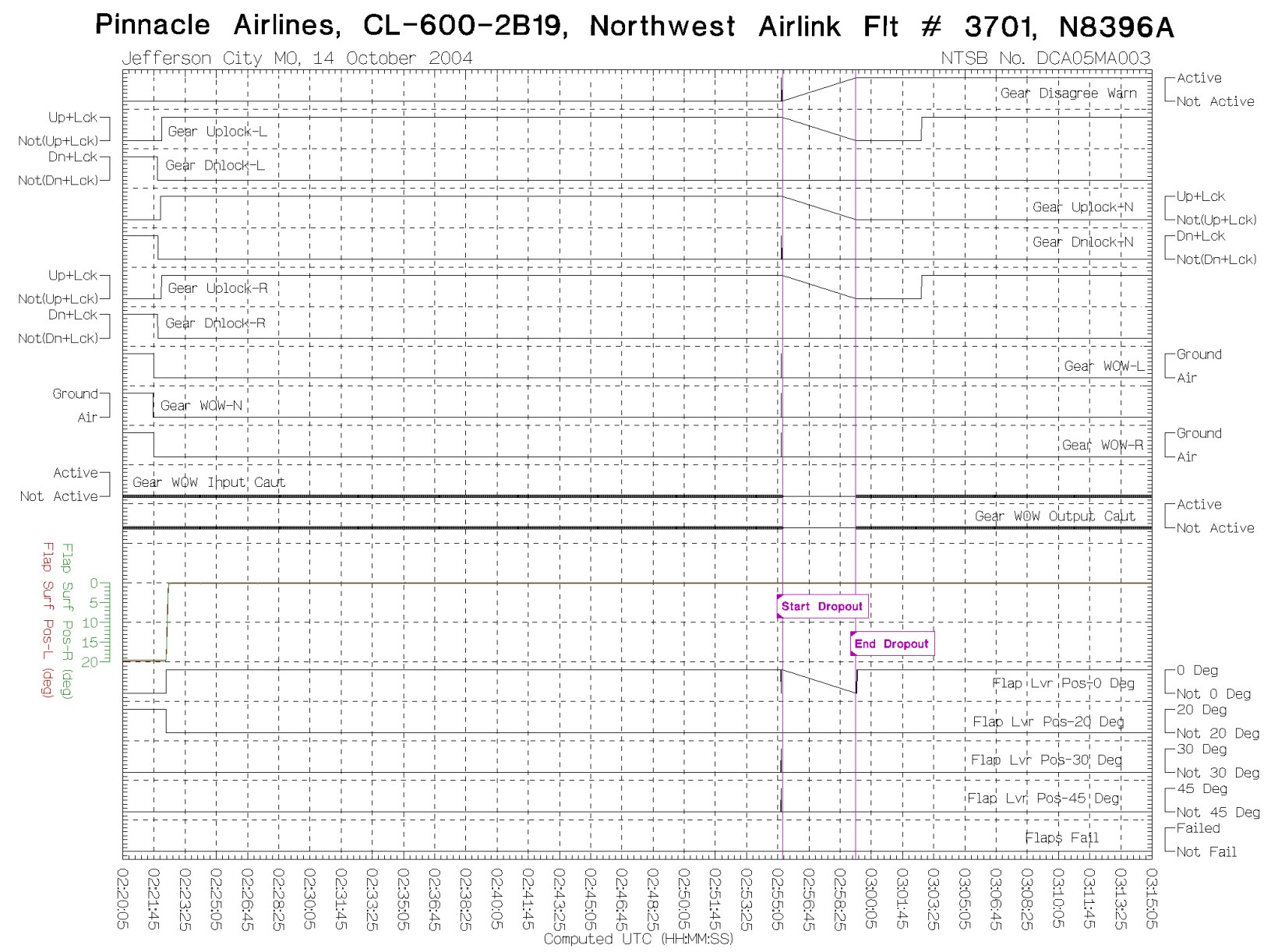
Factual Report Plot 7



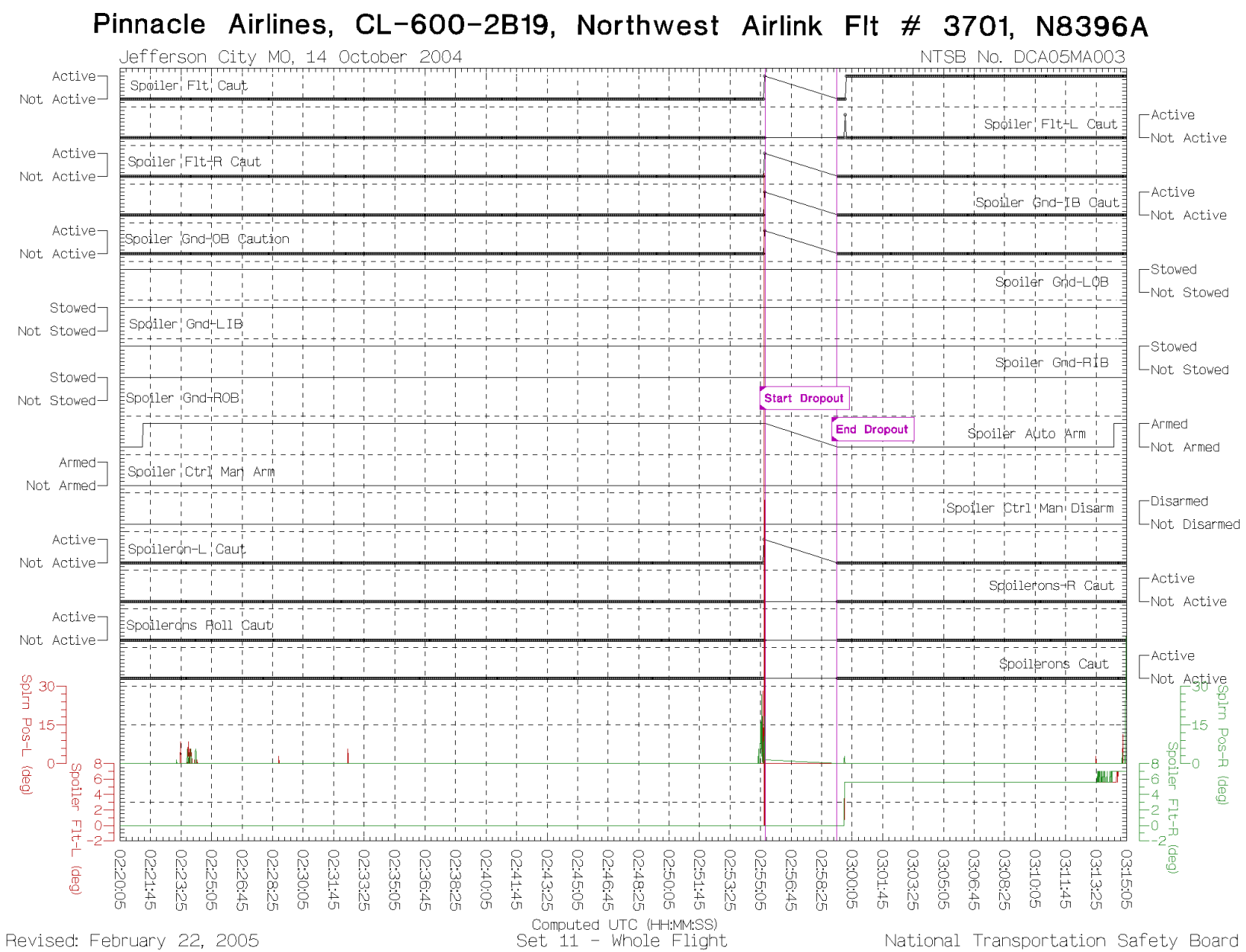
Factual Report Plot 8



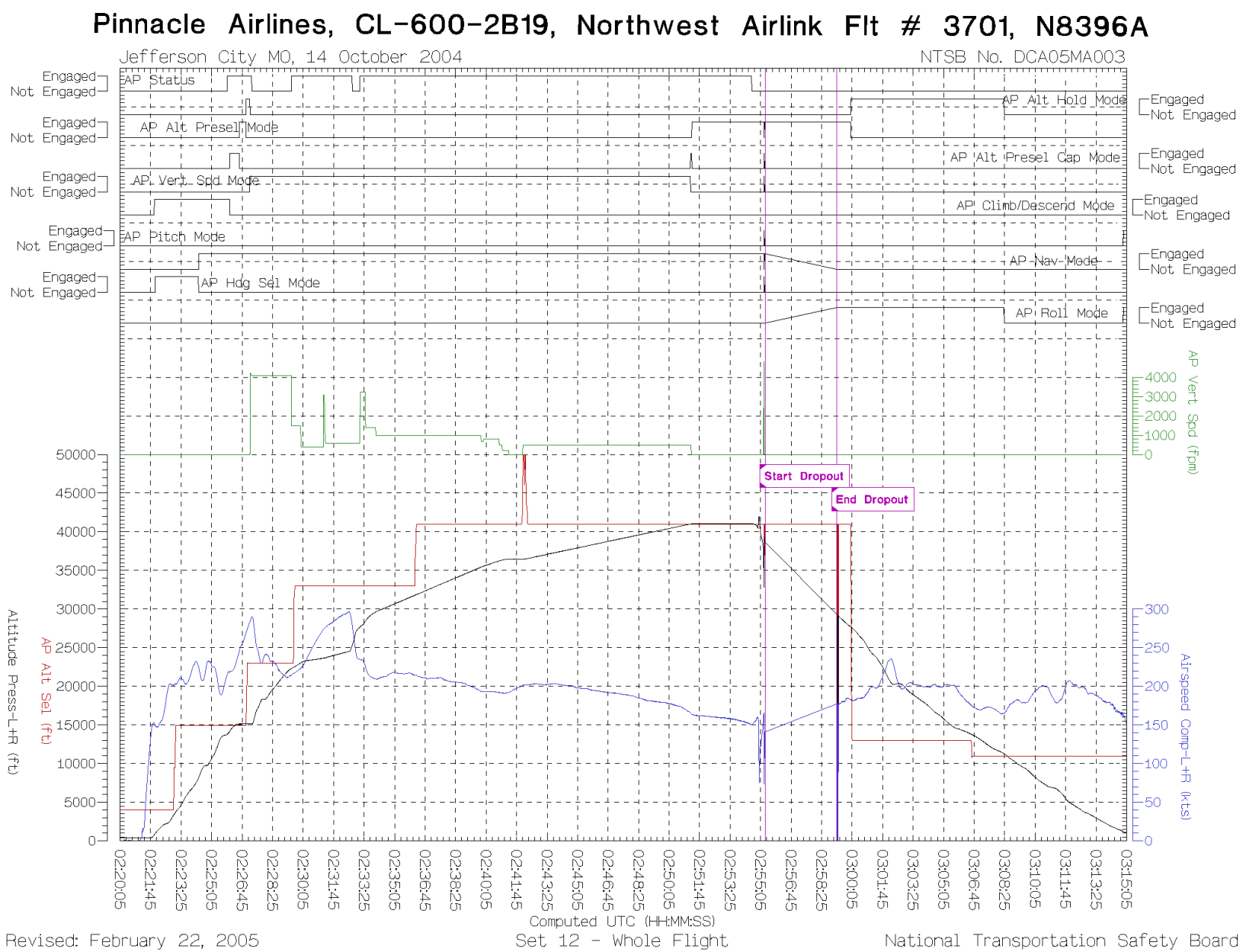
Factual Report Plot 9



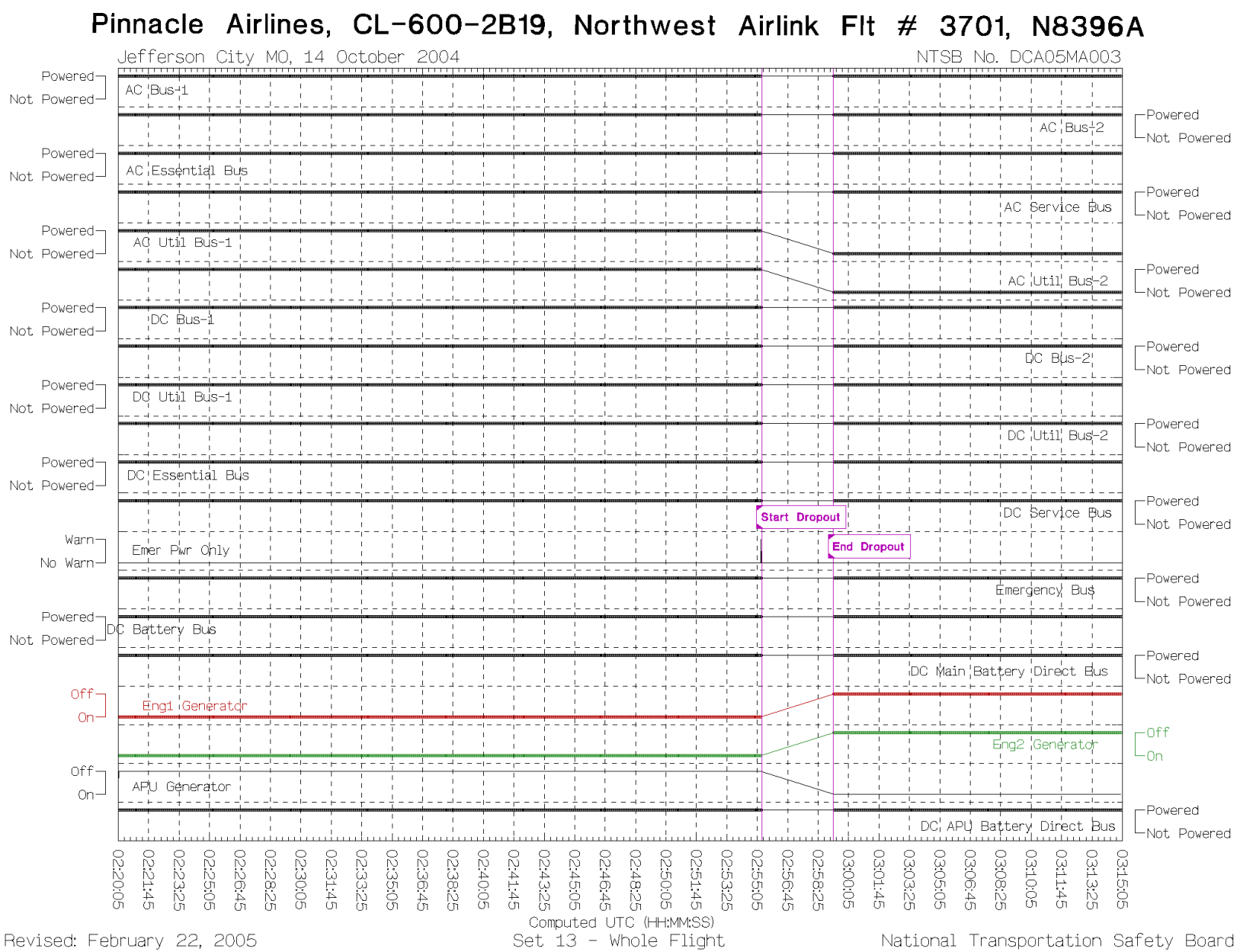
Factual Report Plot 10



Factual Report Plot 11

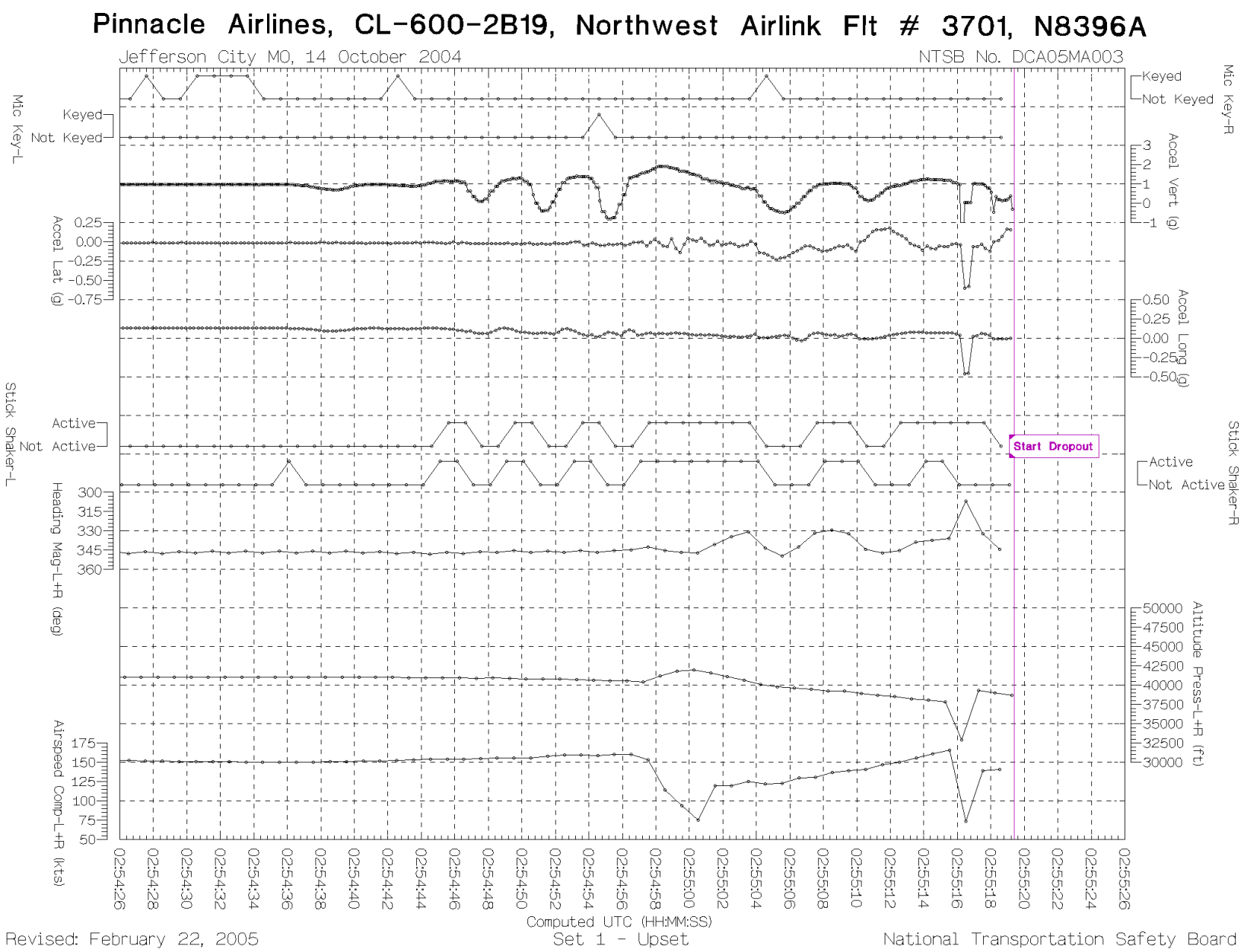


Factual Report Plot 12

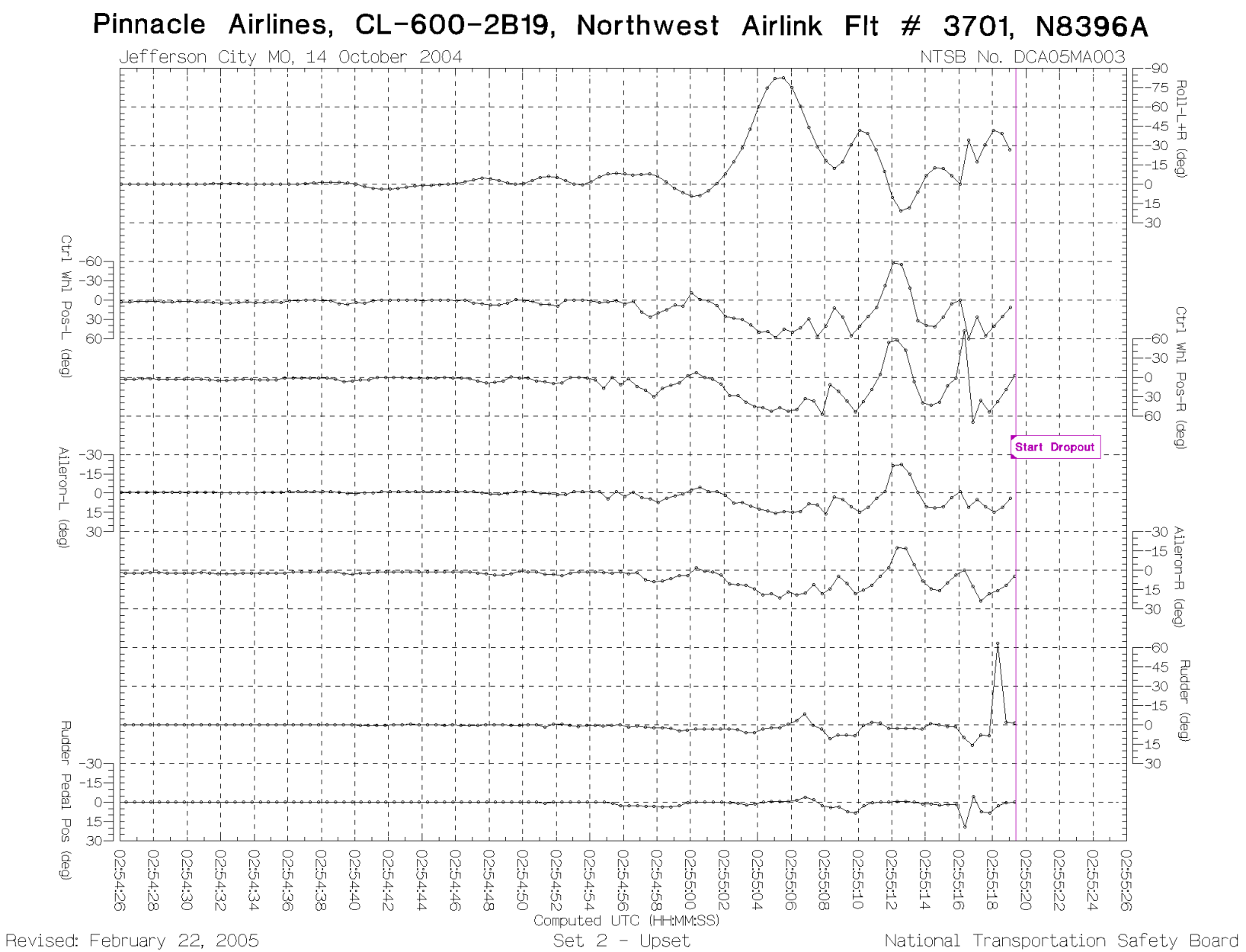


Factual Report Plot 13

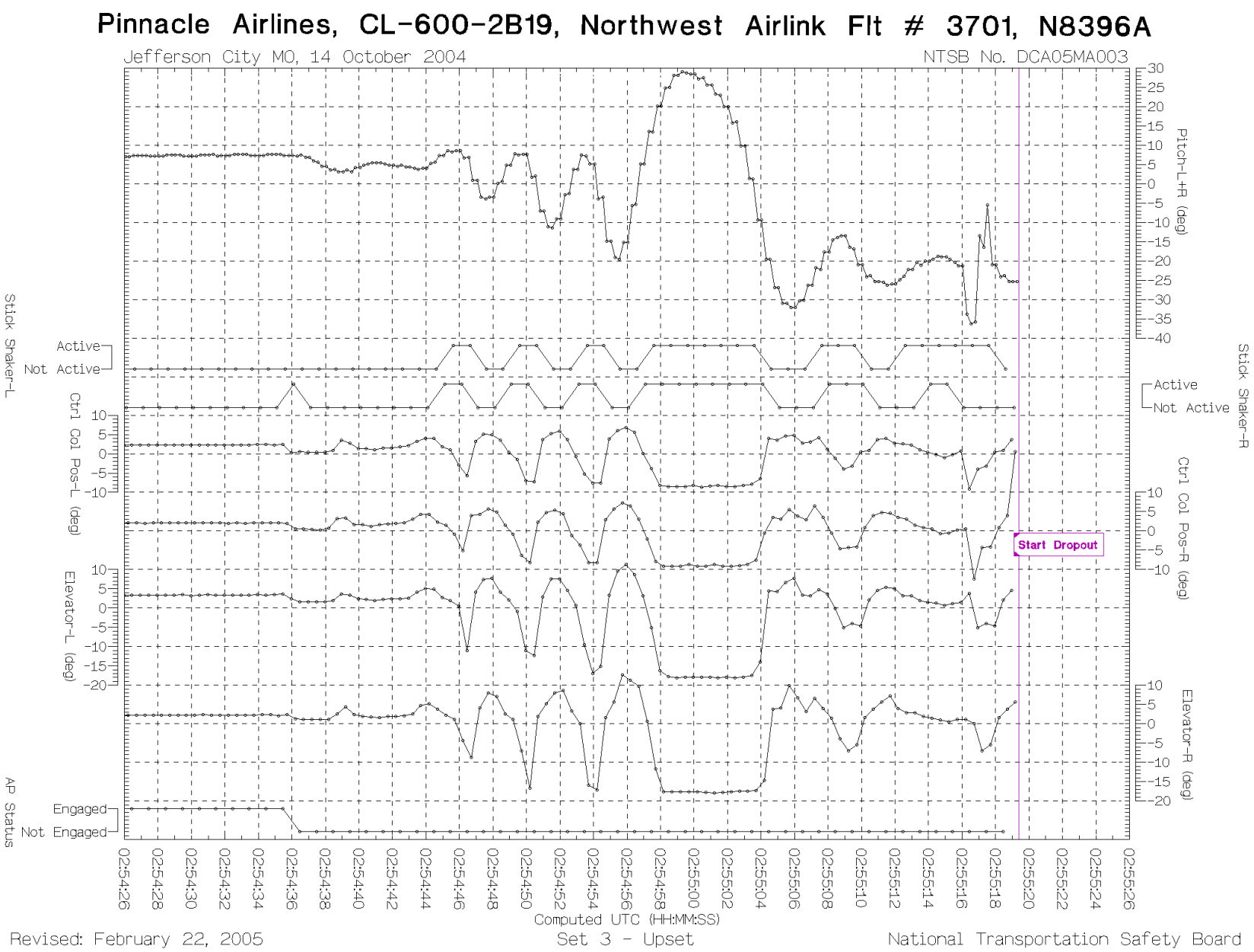
The second group of plots, Plots 14 thru 21, contains the timeframe identified as the “Upset” timeframe. These plots show a detailed view of parameter sets 1 thru 8 for the 60 seconds prior to the data dropout. During this time the aircraft experienced an upset and the power to the FDR was lost. Plots showing this timeframe include a single magenta vertical line marking the start of the data dropout.



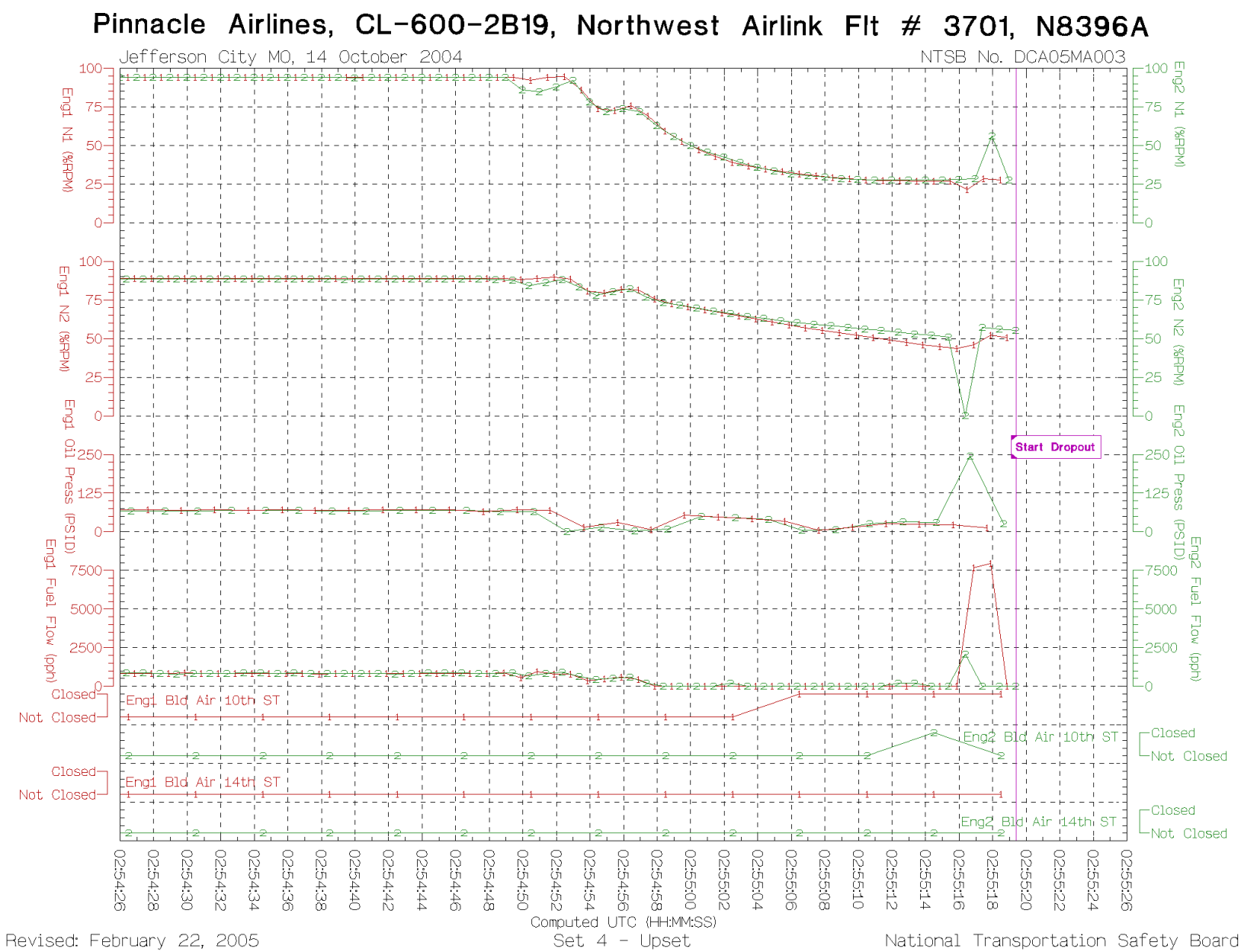
Factual Report Plot 14



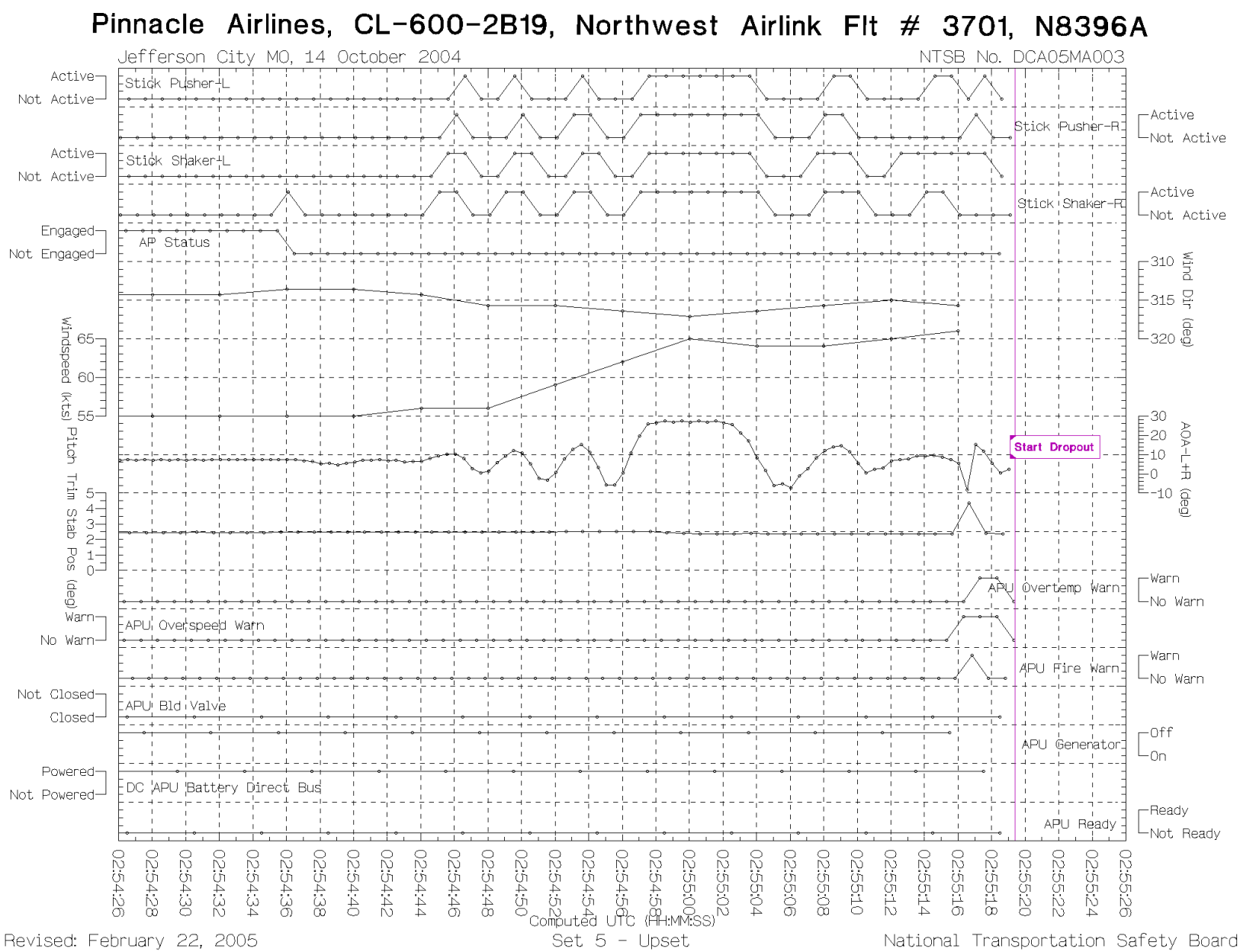
Factual Report Plot 15



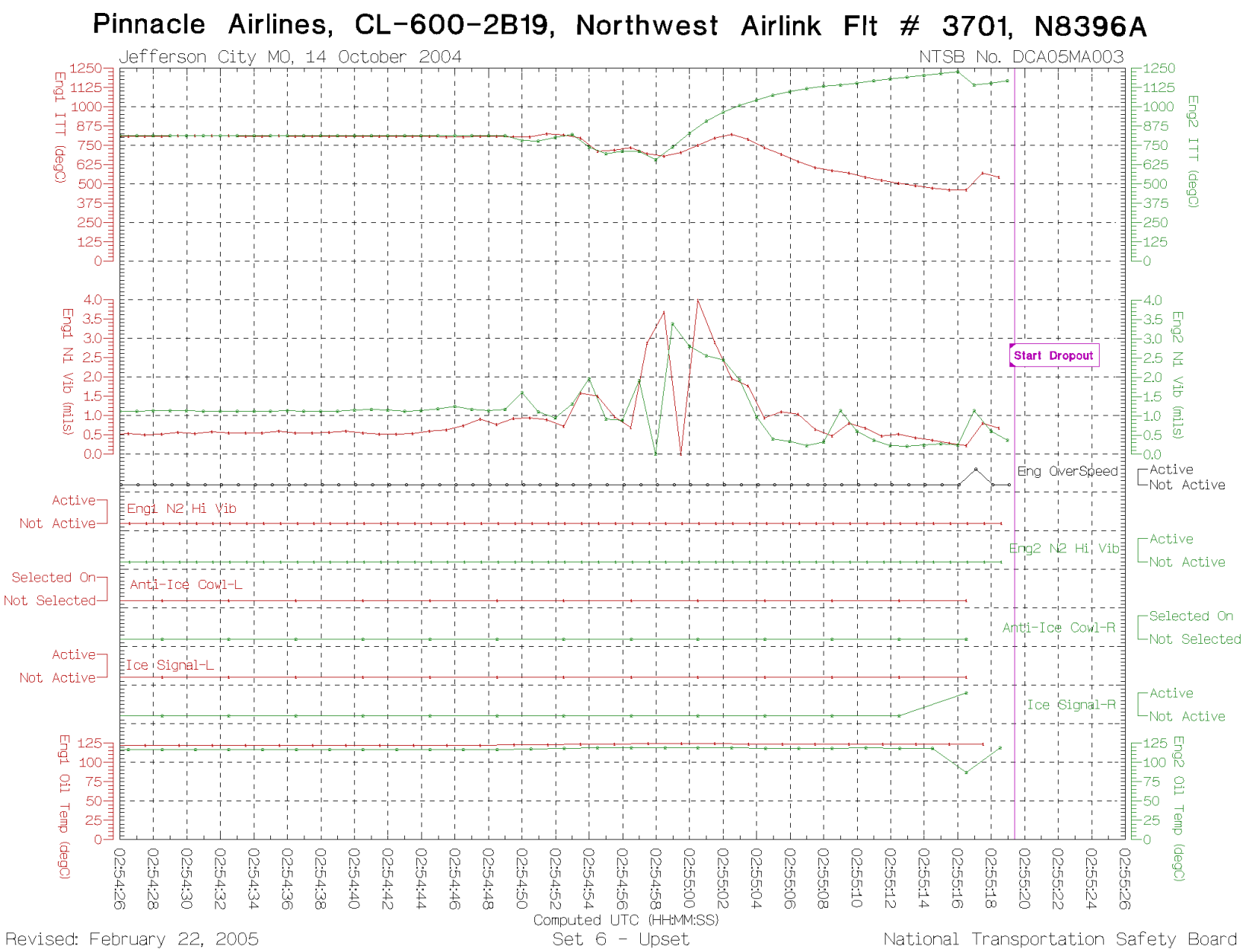
Factual Report Plot 16



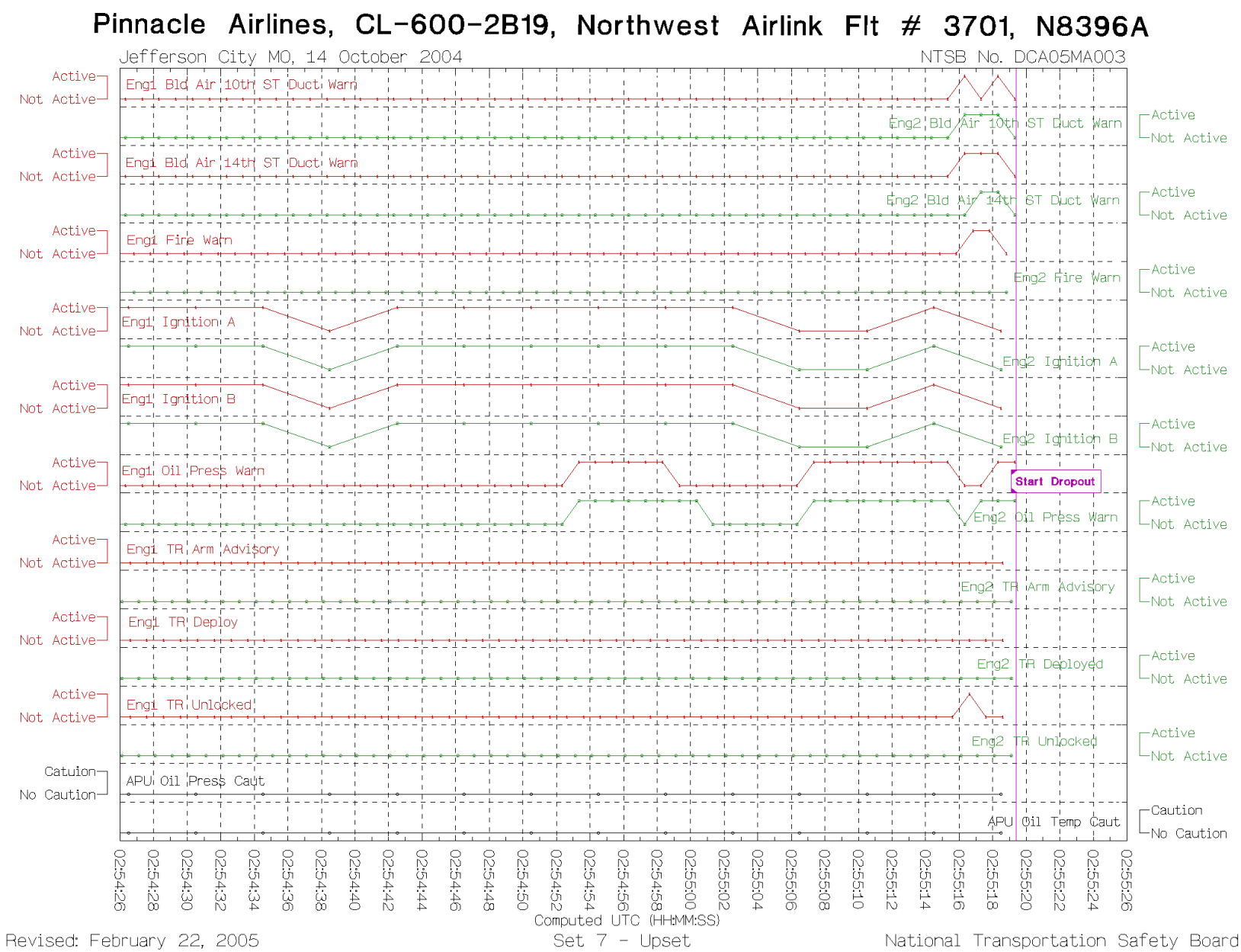
Factual Report Plot 17



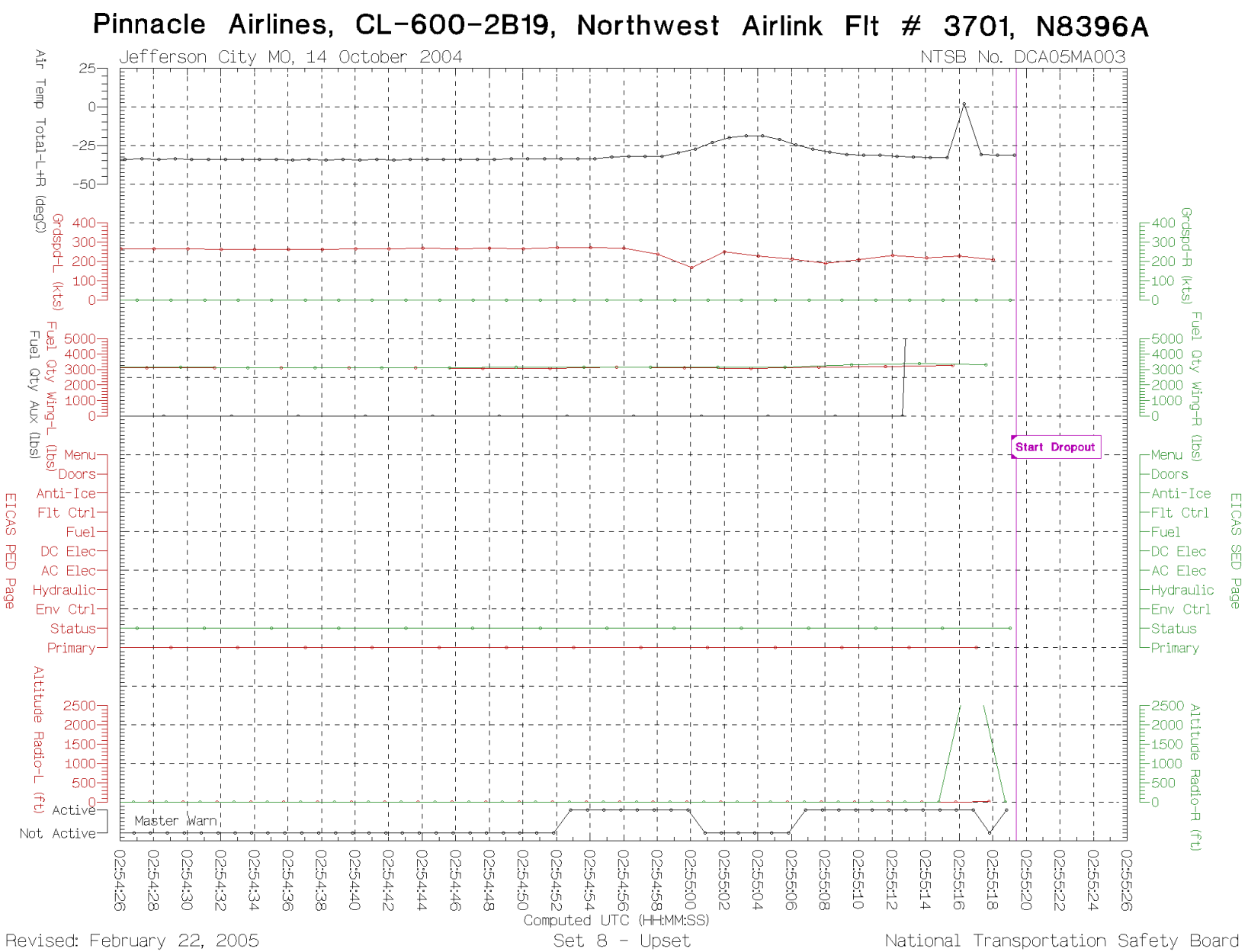
Factual Report Plot 18



Factual Report Plot 19

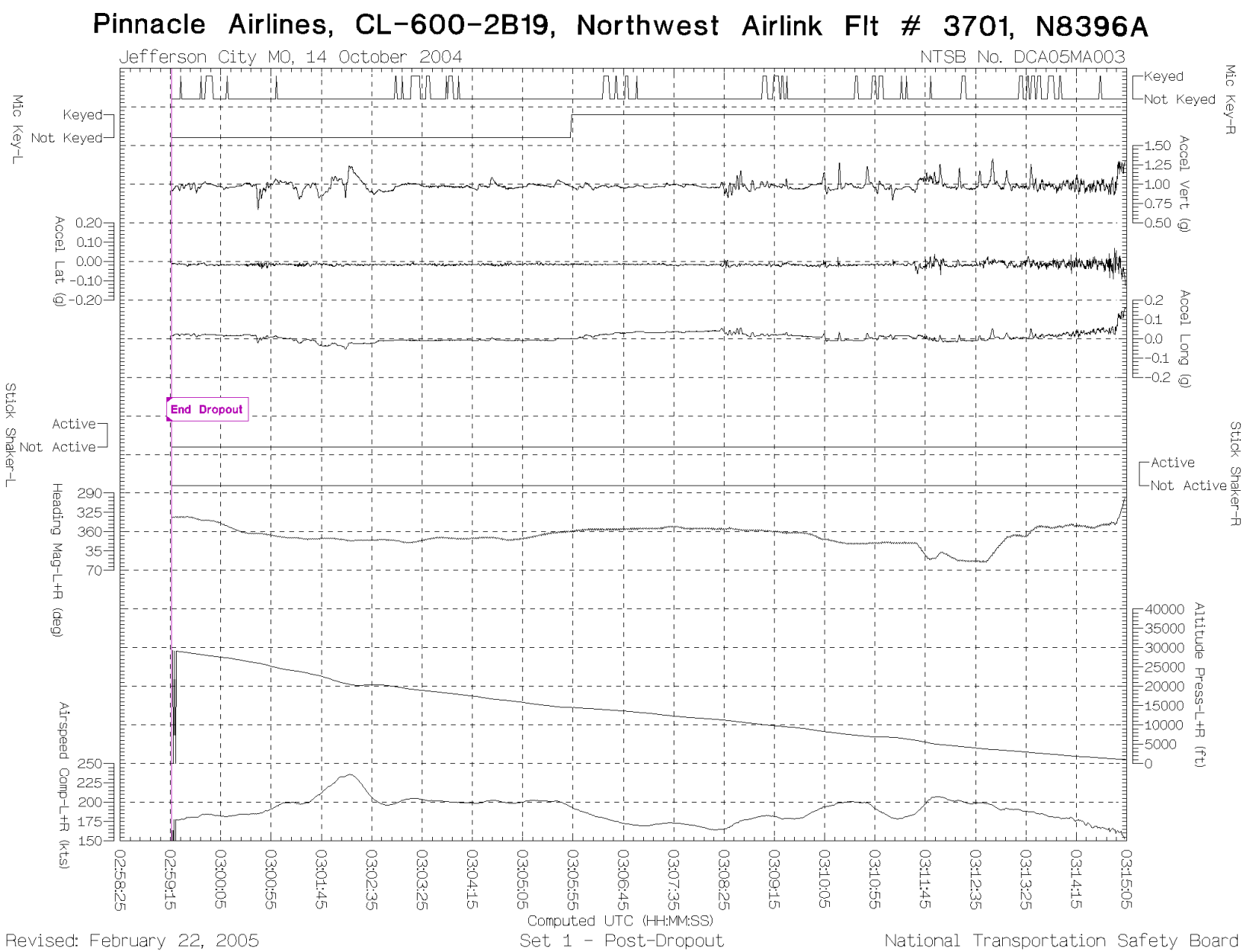


Factual Report Plot 20

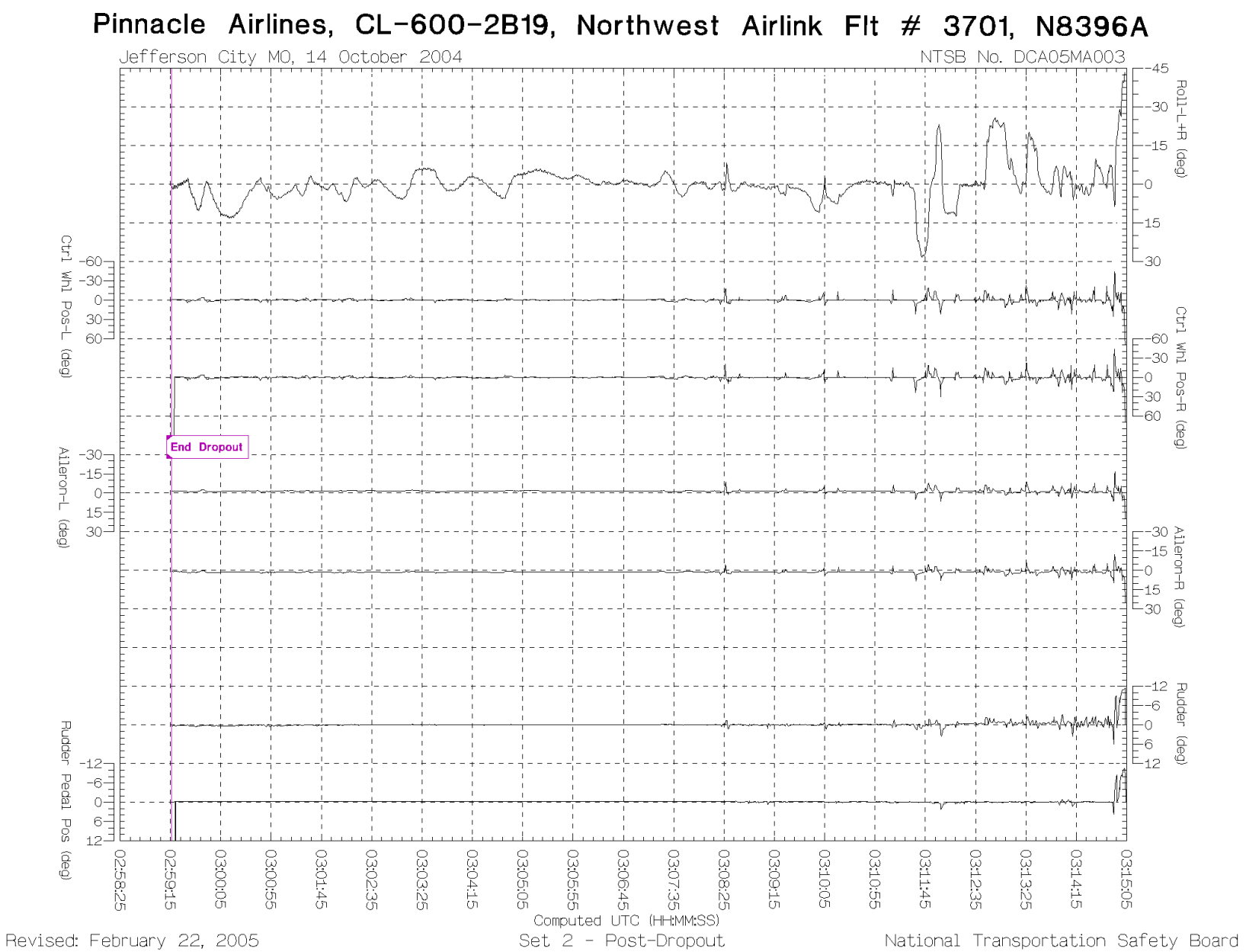


Factual Report Plot 21

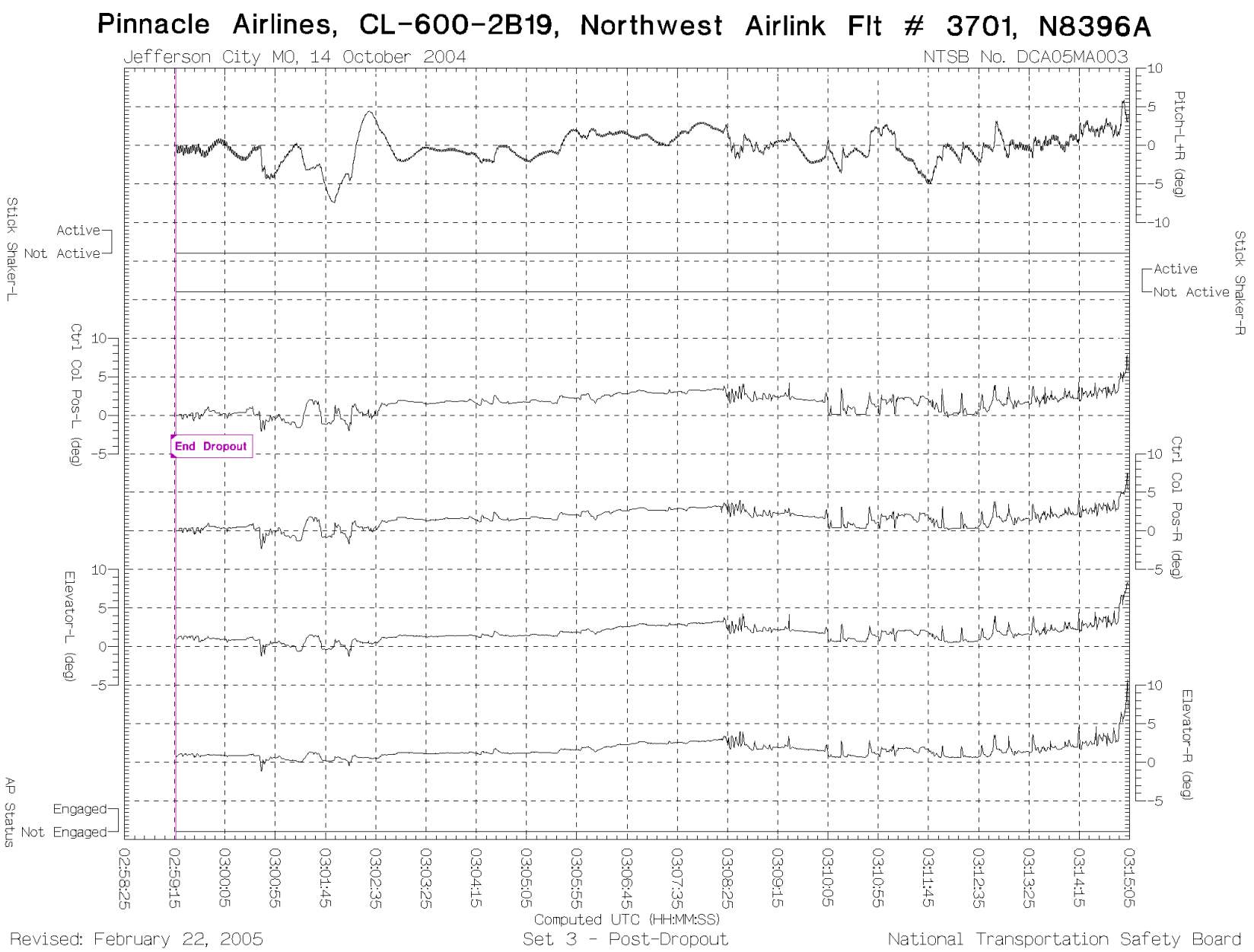
The third group of plots, Plots 22 thru 29, contains the timeframe identified as the “Post-Dropout” timeframe. These plots show a detailed view of parameter sets 1 thru 8 for a time period of 1000 seconds, which covers the time from the end of the dropout to the end of the flight. Plots showing this timeframe include a single magenta vertical line marking the end of the data dropout.



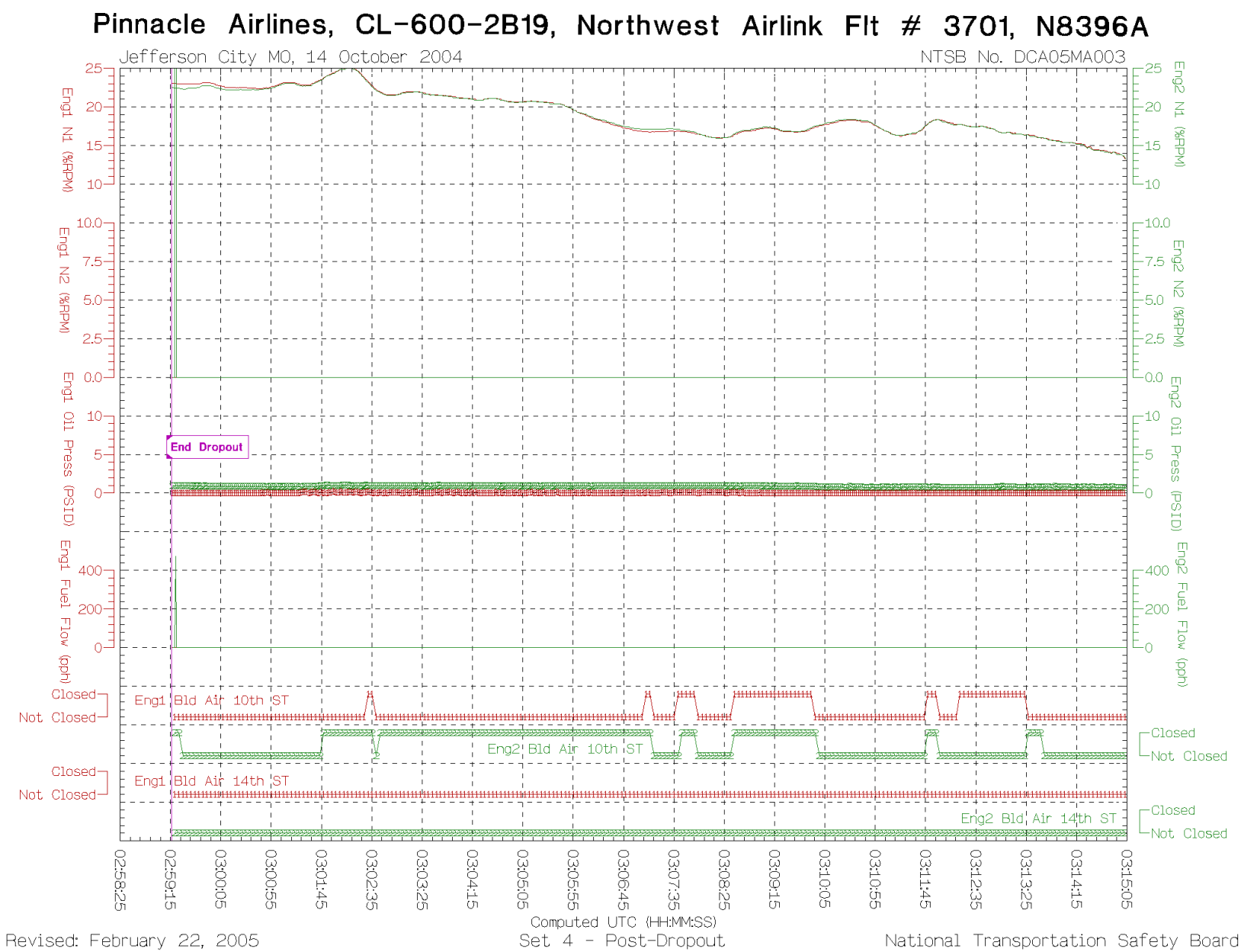
Factual Report Plot 22



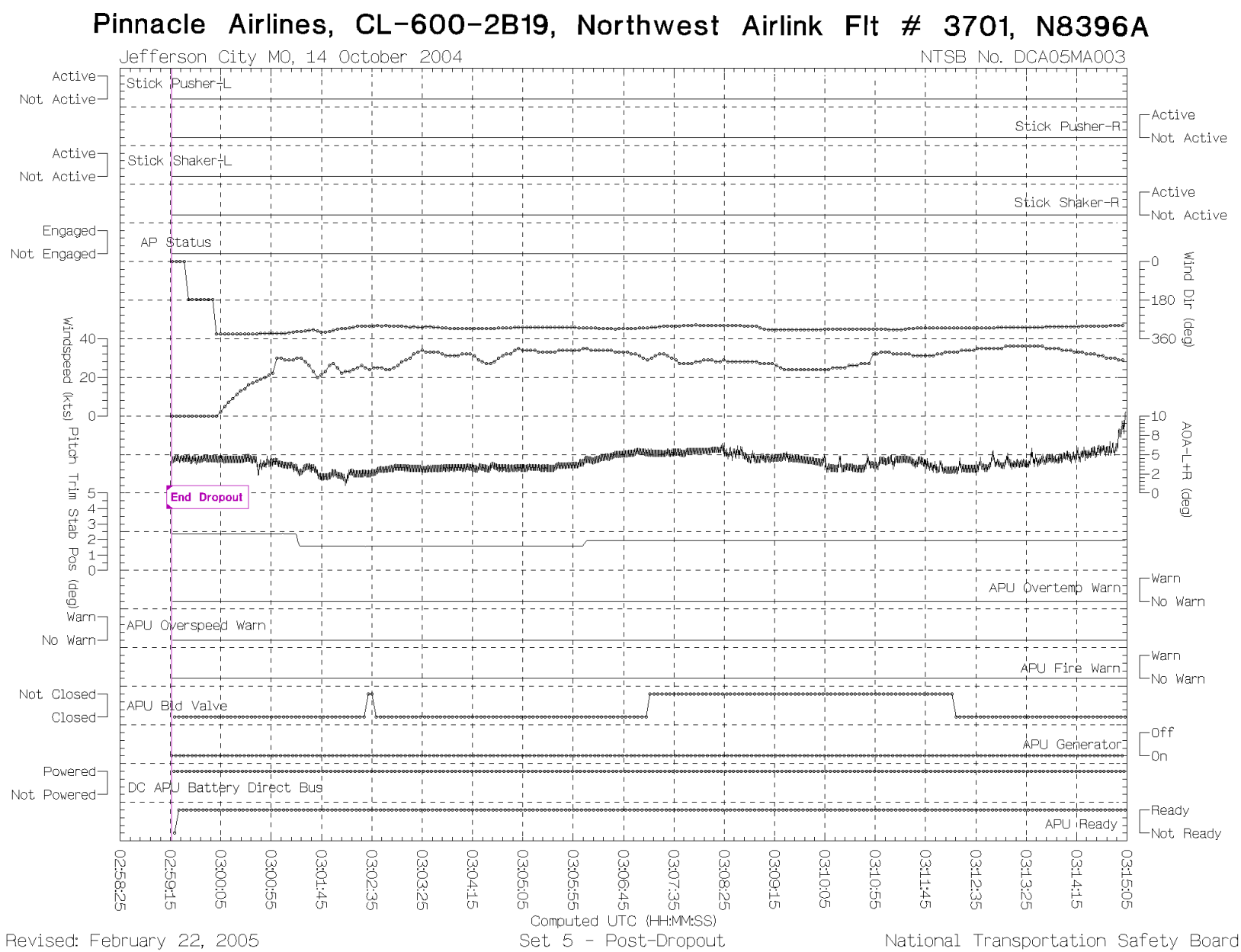
Factual Report Plot 23



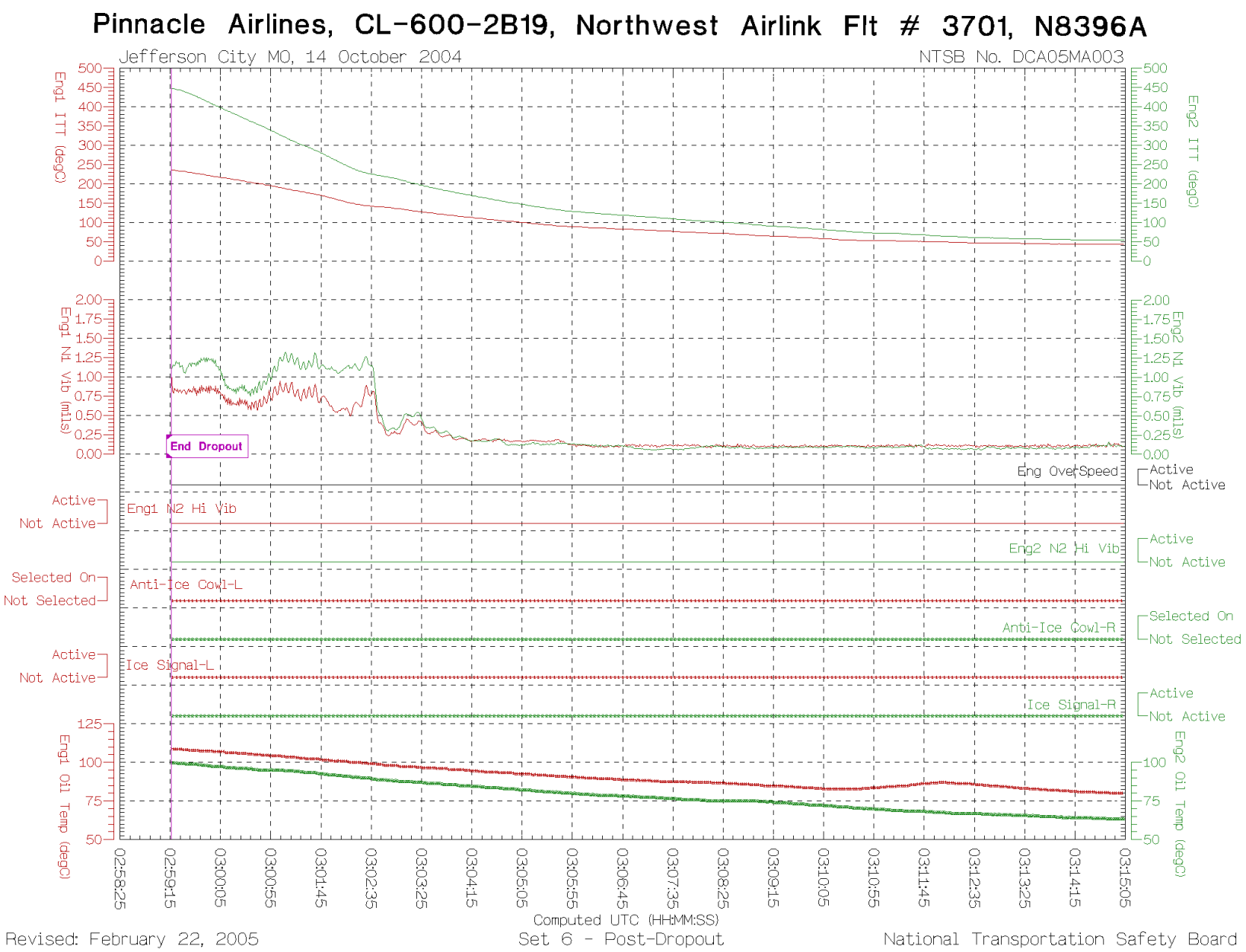
Factual Report Plot 24



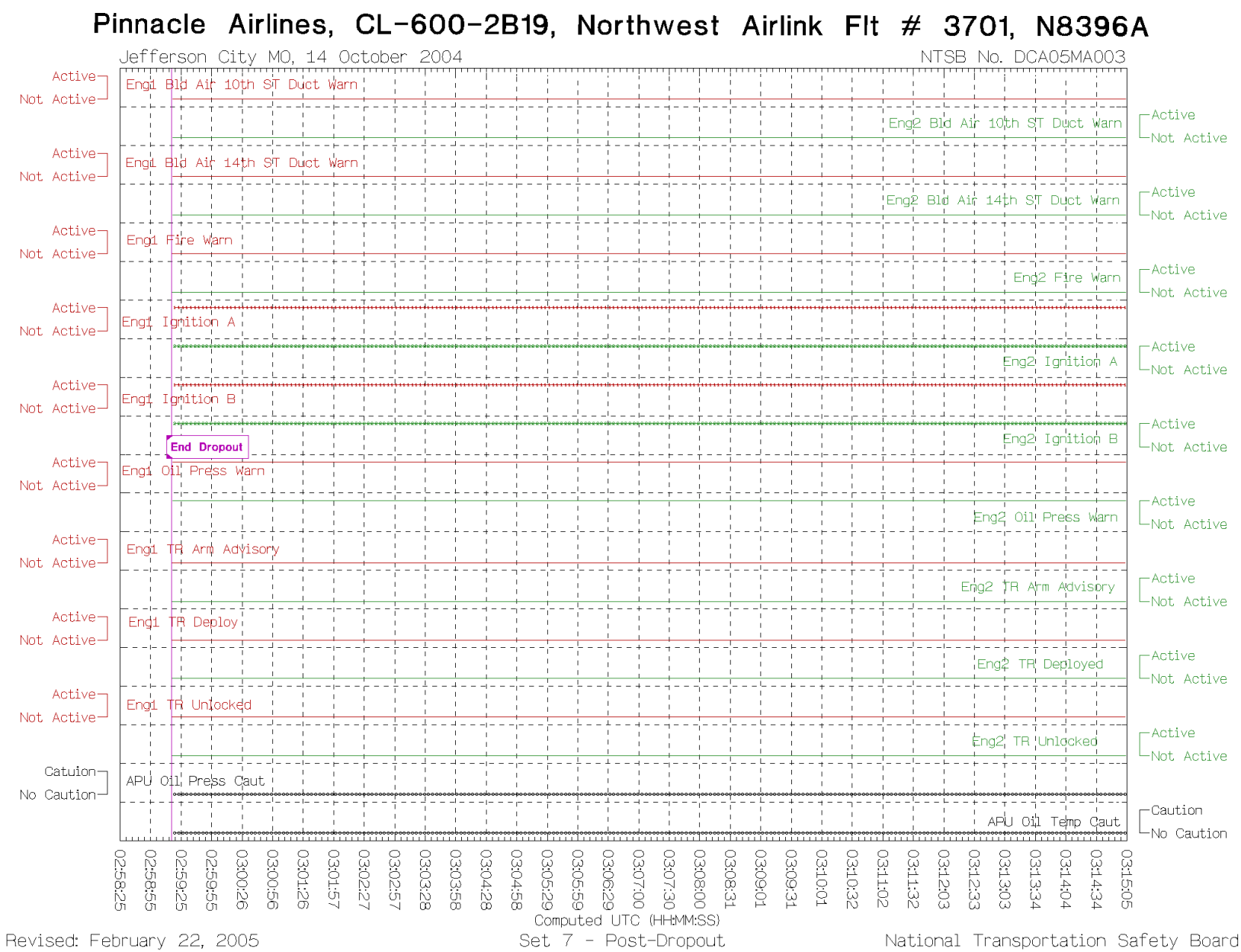
Factual Report Plot 25



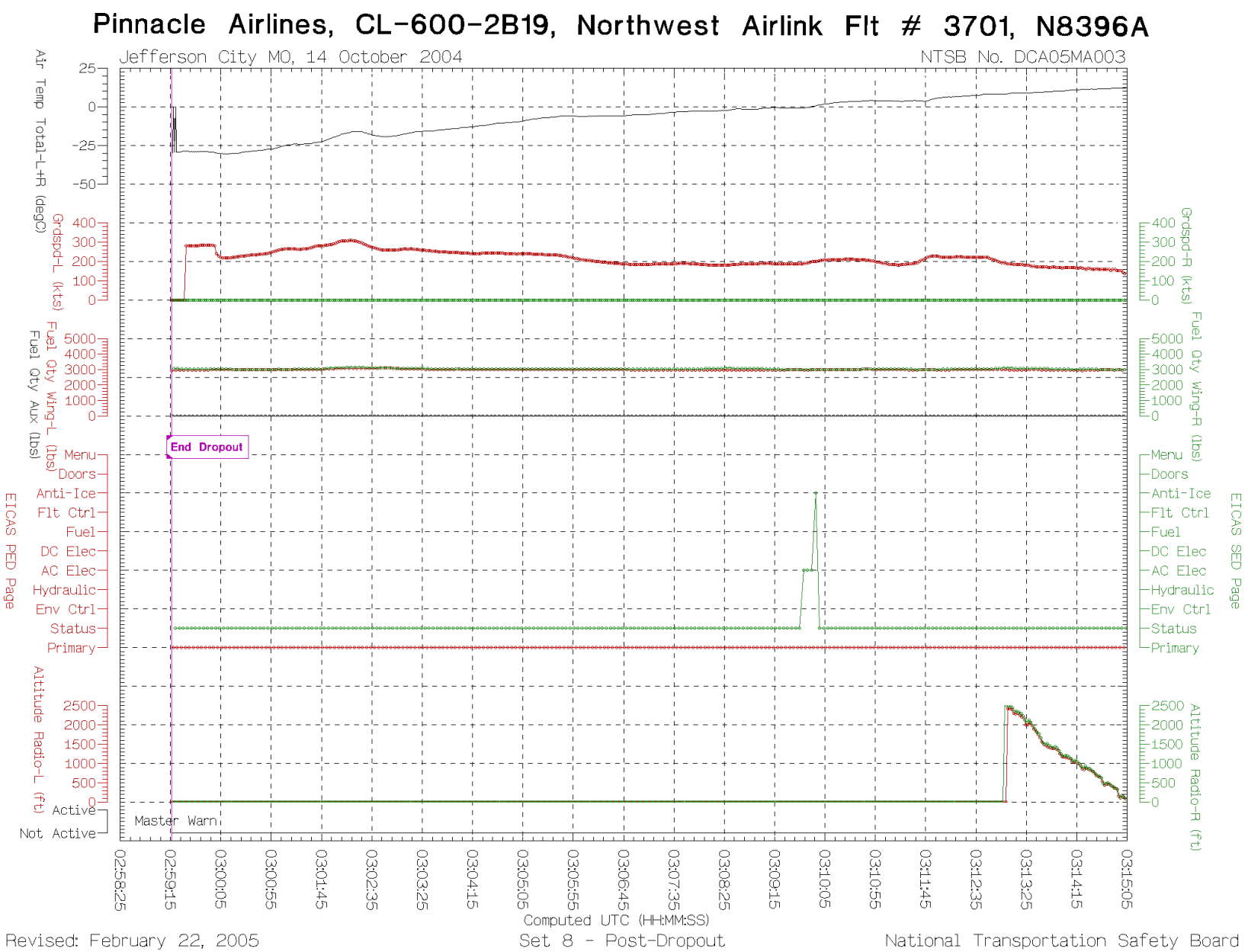
Factual Report Plot 26



Factual Report Plot 27



Factual Report Plot 28



Factual Report Plot 29

The last group of plots, Plots 30 thru 38, contains the several timeframes and parameter sets that the FDR group created to examine specific sections of the interest during the accident flight.

Plot 30 shows data from parameter set 14 for a timeframe identified as “Lead-In to Upset”, which is the 24-minute period that covers the time from approximately 25,000 feet pressure altitude until after the stick shaker activation began and the auto-pilot disengaged. Parameters included in Set 14 are engine N1 and ITT, pitch trim stabilizer position, control column and elevator positions, pitch, AOA, auto-pilot vertical speed selected, computed airspeed (combined left and right), auto-pilot altitude selected, pressure altitude (combined left and right), engine 1 ignition A, right stick shaker, and auto-pilot altitude preselected, altitude preselected captured, vertical speed modes and auto-pilot engagement status. Only engine 1 ignition A was plotted because it is representative of all engine ignitions, which were active at the same time. Only the right stick shaker was plotted because it was the first one to activate, which occurred near the point in time when the auto-pilot disengaged. As the altitude trace increases to about 36,000 feet the airspeed continues to decrease and the pitch angle and AOA gradually increase. The altitude levels off at about 36,400 feet and the airspeed increases to slightly above 200 knots. Then the altitude continues to increase to approximately 41,000 feet, the airspeed bleeds off to about 165 knots, and the pitch and AOA continue to increase to about 6 and 5 degress, respectively. After the altitude levels off at 41,000 feet the airspeed continues to bleed off to about 150 knots as the pitch and AOA continue increasing to about 7.5 degrees at about the same time as the stick shaker activates and the auto-pilot disengages.

Plots 31 thru 33 show data for the timeframe identified as “Upset, Flameout, & Recovery” for parameter sets 15 thru 17 respectively. This timeframe shows an expanded view of the last 55 seconds before the data dropout and has a vertical magenta line marking the start of the dropout. All 3 of these parameter sets have parameters for auto-pilot status, stick shakers and pushers activation, airspeed, altitude, and auto-pilot altitude selected at the bottom third of the plot as a baseline for reference between the plots. Set 15 on Plot 31 also includes elevator and control column positions, pitch, AOA, and vertical acceleration parameters. Set 16 on Plot 32 also includes control wheel, aileron, rudder and rudder pedal positions, roll angle (combined from left and right parameters), magnetic heading, and lateral acceleration parameters. Set 17 on Plot 33 also includes engine N1, N2, fuel flow, oil pressure, ITT, roll angle (combined) and AOA parameters.

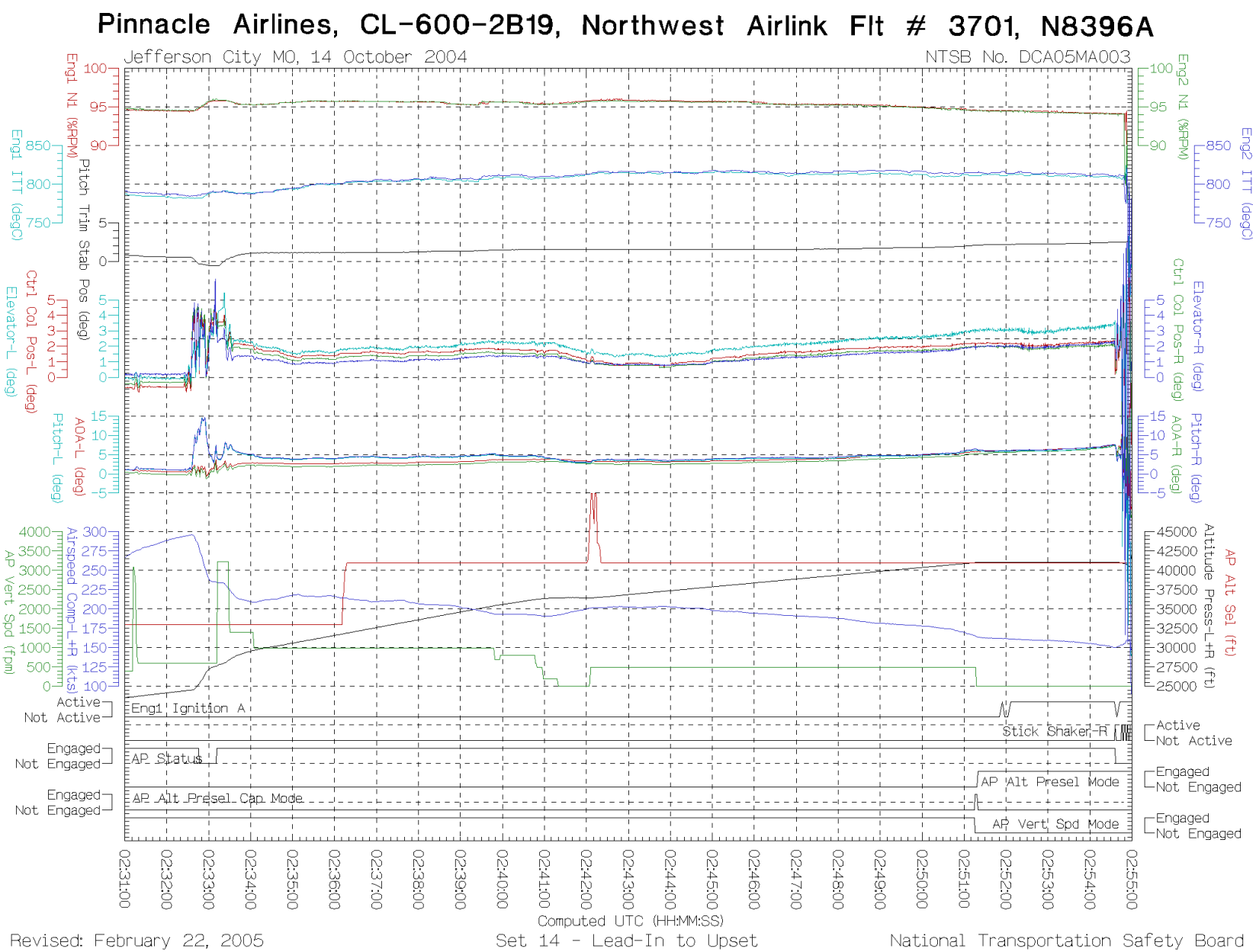
These plots show that at about 02:54:36Z the right stick shaker activated and the auto-pilot disengaged. At this time the control column returns to a neutral position, and the pitch, AOA, and vertical acceleration begin to decrease. The decrease was halted when the control column showed aft movement until the stick shakers and pushers began activating. The stick pushers activated three times for 1-2 second duration at about a 2-3 second interval. After each of the activations, the control column moved aft and put the aircraft in a nose up pitch attitude, the pitch oscillations becoming greater each time. At about 02:54:57Z the pushers activate for about 8 seconds as the pitch goes through its largest oscillation. As the pitch goes through the highest point of the oscillation, about 30 degrees nose up, airspeed drops off to around 75 knots. The pitch then goes to about 30 degrees nose down and airspeed increases back up to about 125 knots. For the last 12

seconds before the data drop out the pitch continues to oscillate around the 20 degrees nose low point with lessening severity, the stick pushers activating 2 more times. During the upset, there were six times that the vertical acceleration was reduced to near or less than zero G's. The greatest of these deviations was about -0.8 G's. The roll angle varied between about +/- 10 degrees until after the largest pitch oscillation. As the pitch was dropping from 30 degrees nose up to 30 degrees nose down the roll increased to about 82 degrees left wing down. As the pitch and AOA oscillations began to decrease the roll continued to oscillate until the data dropout occurred. During the time of largest roll oscillations (02:55:04Z to 02:55:13Z) the lateral acceleration varied between about +/- 0.25 G's. About the time of the second stick pusher activation (02:54:49Z) the engine N1 and N2 speeds begin to fluctuate and decline. At about 02:54:58Z the fuel flow for both engines hit zero. Engine 1 fuel flow stayed there until the suspect period of time just before the dropout. Engine 2 spiked occasionally prior to the dropout, which, per the engine manufacturer, indicates a slight amount of fuel flow, as opposed to the complete lack of fuel flow on engine 1. After the initial fluctuation of the engines the ITT on engine one oscillated one more time before dropping below 500 degrees C. Engine 2 ITT ramped up after the initial 2 oscillations to nearly 1250 degrees C.

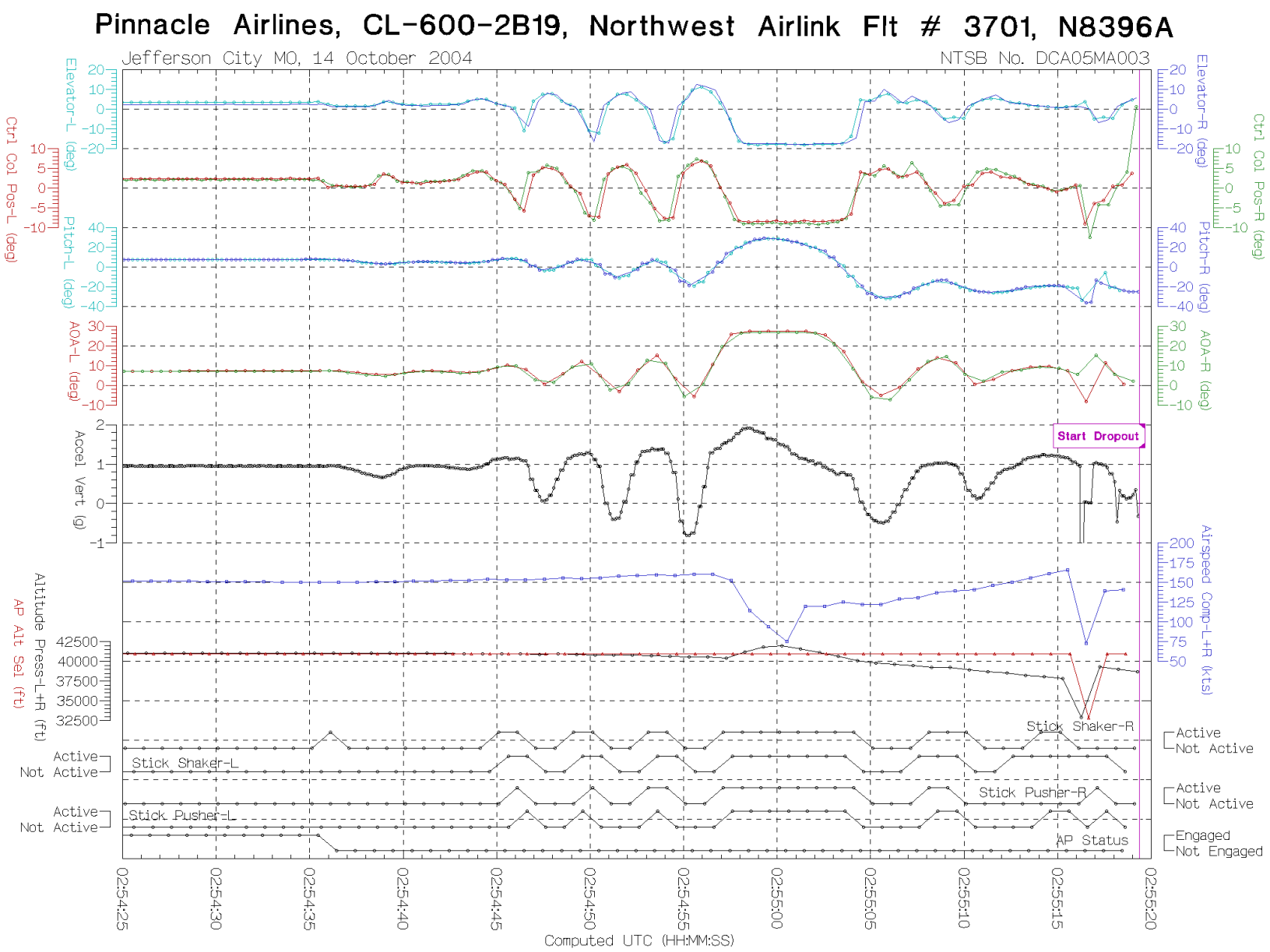
Plot 34, containing parameter Set 18, is of the region identified as the "Restart Envelope". This timeframe begins when the FDR comes back after the dropout and continues until the aircraft is below 5000 ft altitude (02:59:10Z to 03:12:30Z). As described above, the first 5 seconds after the data dropout is suspect. Parameter Set 18 contains engine N1, N2, fuel flow, oil pressure, and ITT parameters, combined parameters for total air temperature, pressure altitude, and airspeed, and discreet parameters for engine 10^{th} stage bleed air valves, APU bleed air valve, APU generator, and engine ignition for both igniters on both engines. When this timeframe begins the altitude is about 29000 ft and airspeed is about 177 knots. Both engine N2 parameters are at 0% and do not change for the duration of this timeframe. The fuel flow for both engines also stays at 0 for the timeframe and engine oil pressures stay at points near 0 and 1 PSID for engines 1 and 2 respectively. When the altitude is about 25000 ft the airspeed increases to about 200 knots for about 30 seconds then continues to increase to about 235 knots. As the airspeed reaches 235 knots the altitude levels off at about 20300 ft for about 30 seconds then continues decreasing and the airspeed maintains about 200 knots. At about 03:01:41Z, as the airspeed was increasing, the engine 2 10^{th} stage bleed air valve indicates closed, the engine 1 10^{th} stage valve still indicating not closed and the APU bleed air valve indicating closed. At about 03:02:30Z, after as the airspeed is coming back down from 235 knots, the engine 1 10^{th} stage valve indicates closed and the APU valve indicates not closed for about 8 seconds before switching back to not closed and closed, respectively. The same time those switch back, the engine 2 10^{th} stage valve momentarily indicates not closed for one sample before indicating closed again. They remain in this state until about 03:07:05Z. At this time the altitude is about 13000 ft and airspeed is about 170 knots. The engine 1 10^{th} stage valve indicates closed for about 8 seconds. Then at about 03:07:10Z the APU bleed air valve indicates not closed, staying in that state until about 03:12:15Z. During the time the APU valve is not closed, the 10^{th} stage valves open and close 3 times in unison for varying amounts of time. Both are in the not closed state when the APU changes back to closed. Each 10^{th} stage valve makes one more closed/not closed cycle independently after the APU valve is closed and continuing past the end of the timeframe covered on Plot 34. See Plots 4 and 25 for 10^{th} stage valve

positions for the entire flight and post-dropout time periods, respectively. All engine ignitions remained active and the APU generator was on for this entire timeframe.

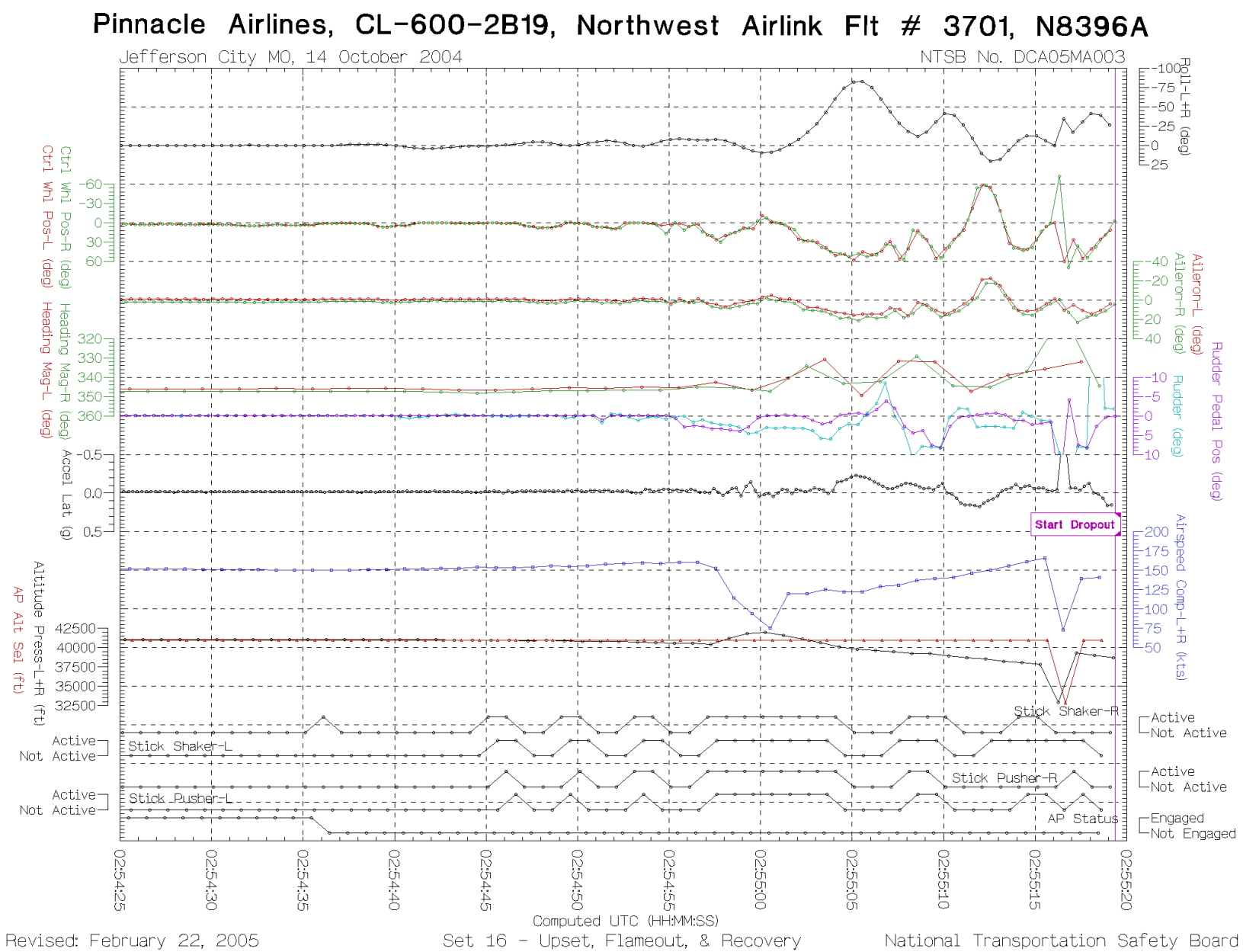
Plots 35 thru 38 show data for the timeframe identified as “End of Flight” for parameter sets 1 thru 3 and 19, respectively. This timeframe shows an expanded view of the last 200 seconds before the end of the recorded data. Sets 1 thru 3 contain the same parameters identified above. Set 19 contains roll (combined), left and right pitch, left AOA, left and right control wheel, left and right aileron position, airspeed (combined), left ground speed, rudder position, rudder pedal position, left and right radio altitude, pressure altitude, and left and right magnetic heading parameters. At about 03:13:05Z the radio altitude began recording a non-zero value indicating the aircraft was no longer above 2500 ft above ground level. Control inputs and surfaces continued to show consistent movement (i.e. deflection consistent with direction of command) for the duration of the timeframe. About 10 seconds before the end of recording the roll indicates a left bank and continues left although the control wheels and aileron positions are commanding a right bank correction. The recording ended with the roll angle approximately 42 degrees left wing down and the control wheel approximately 60 degrees to the right. Airspeed was about 152 knots and ground speed was about 127 knots. The aircraft was turning left and recording ended with a magnetic heading of about 300 degrees. Pressure altitude was about 1250 ft.



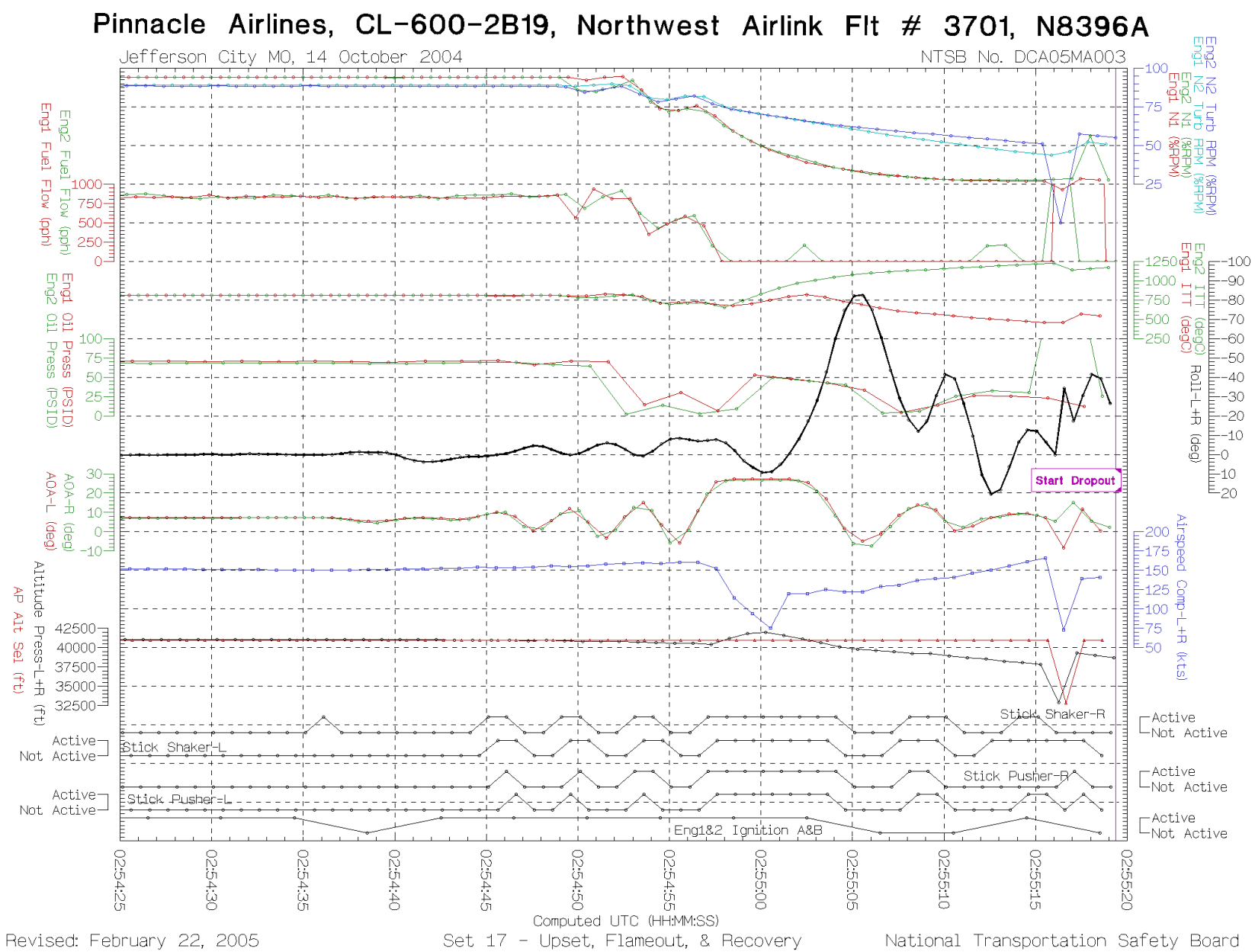
Factual Report Plot 30



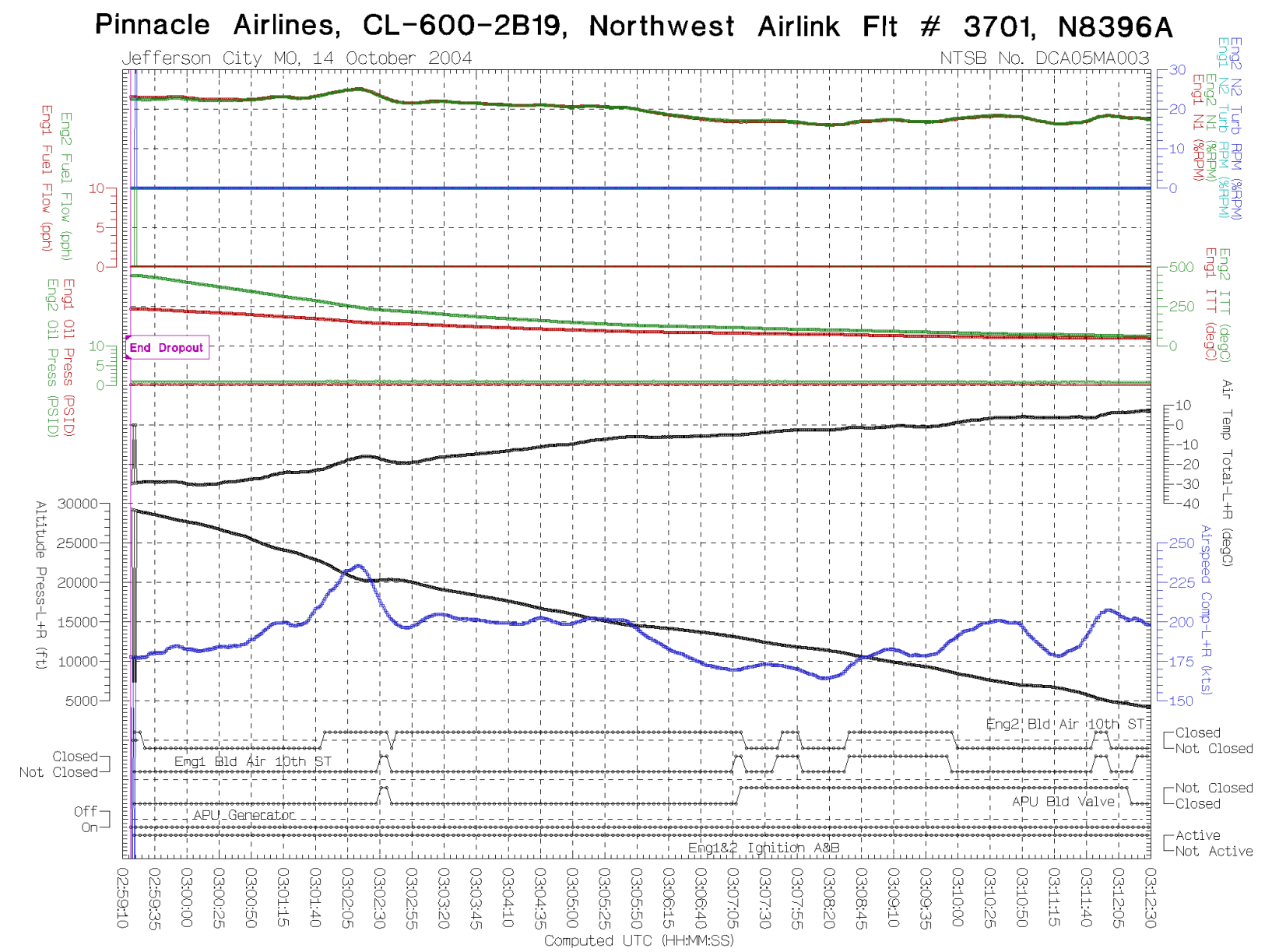
Factual Report Plot 31



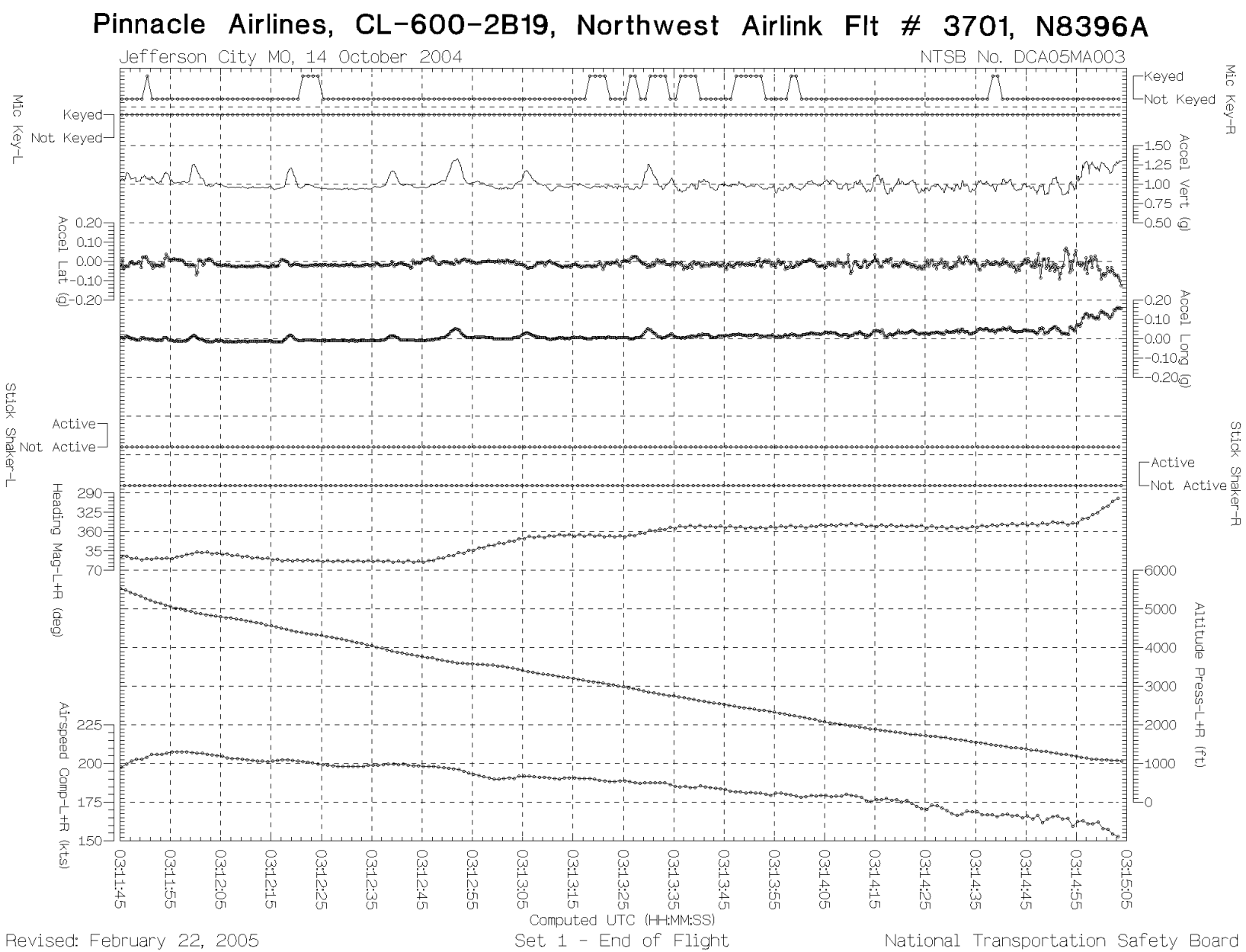
Factual Report Plot 32



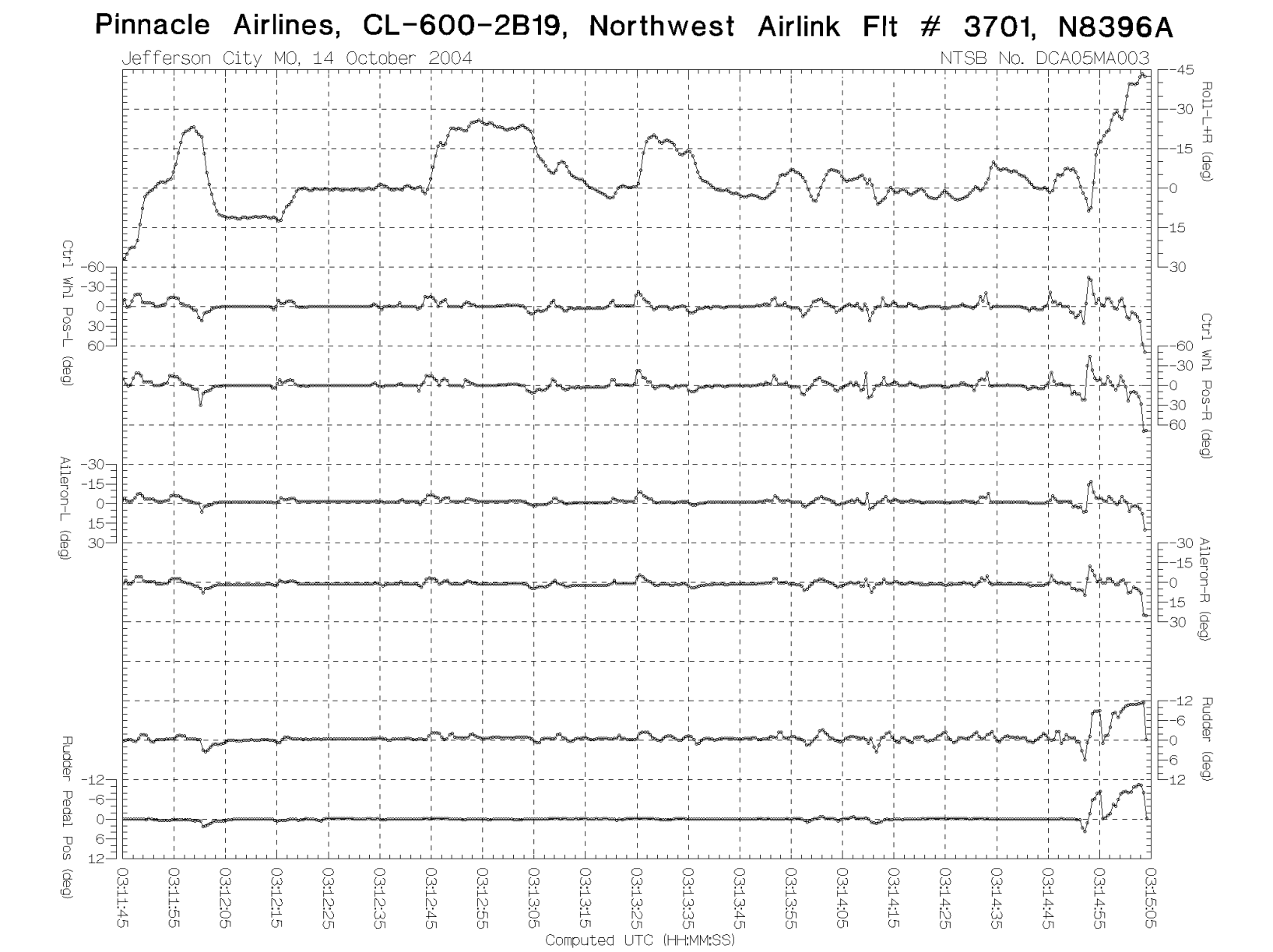
Factual Report Plot 33



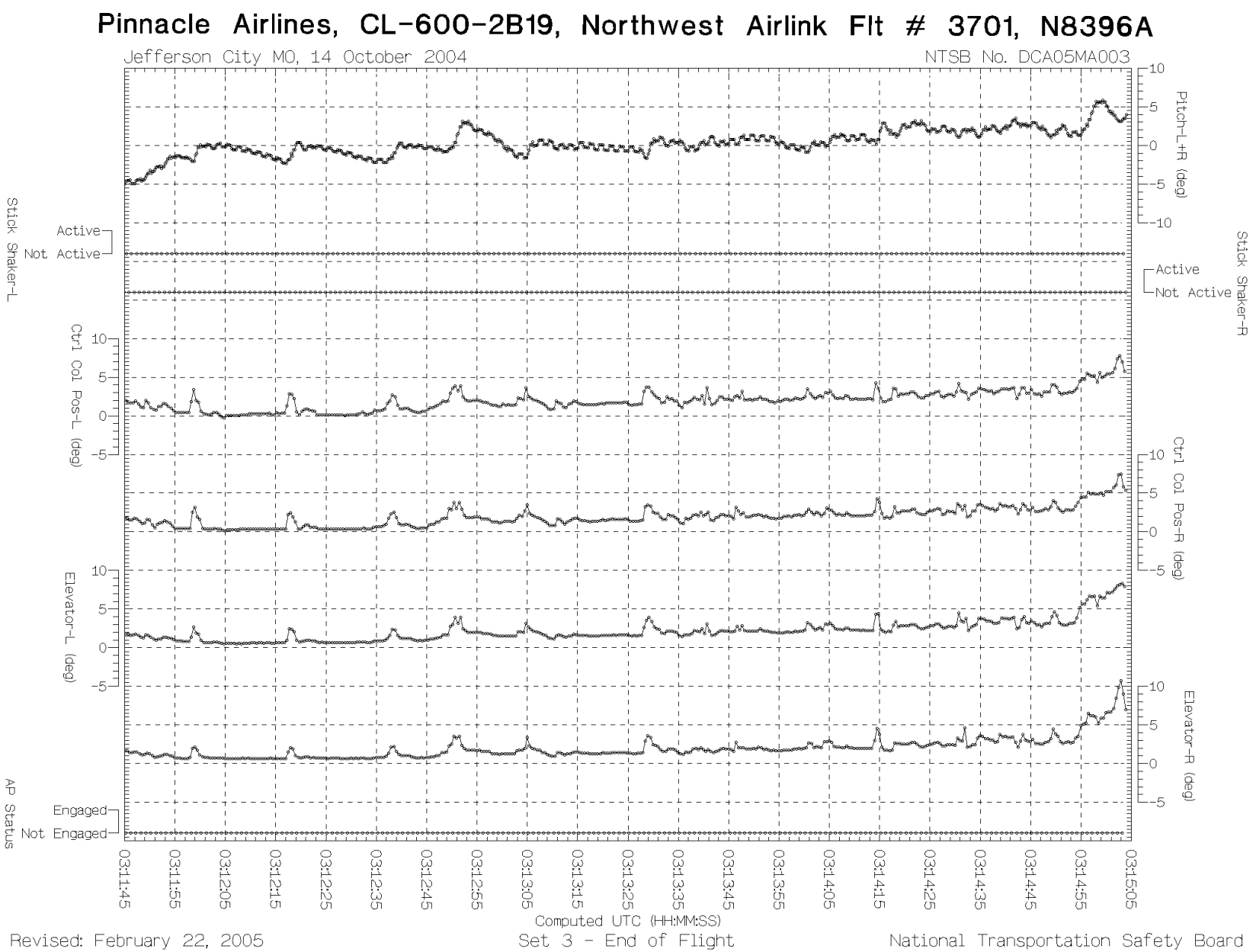
Factual Report Plot 34



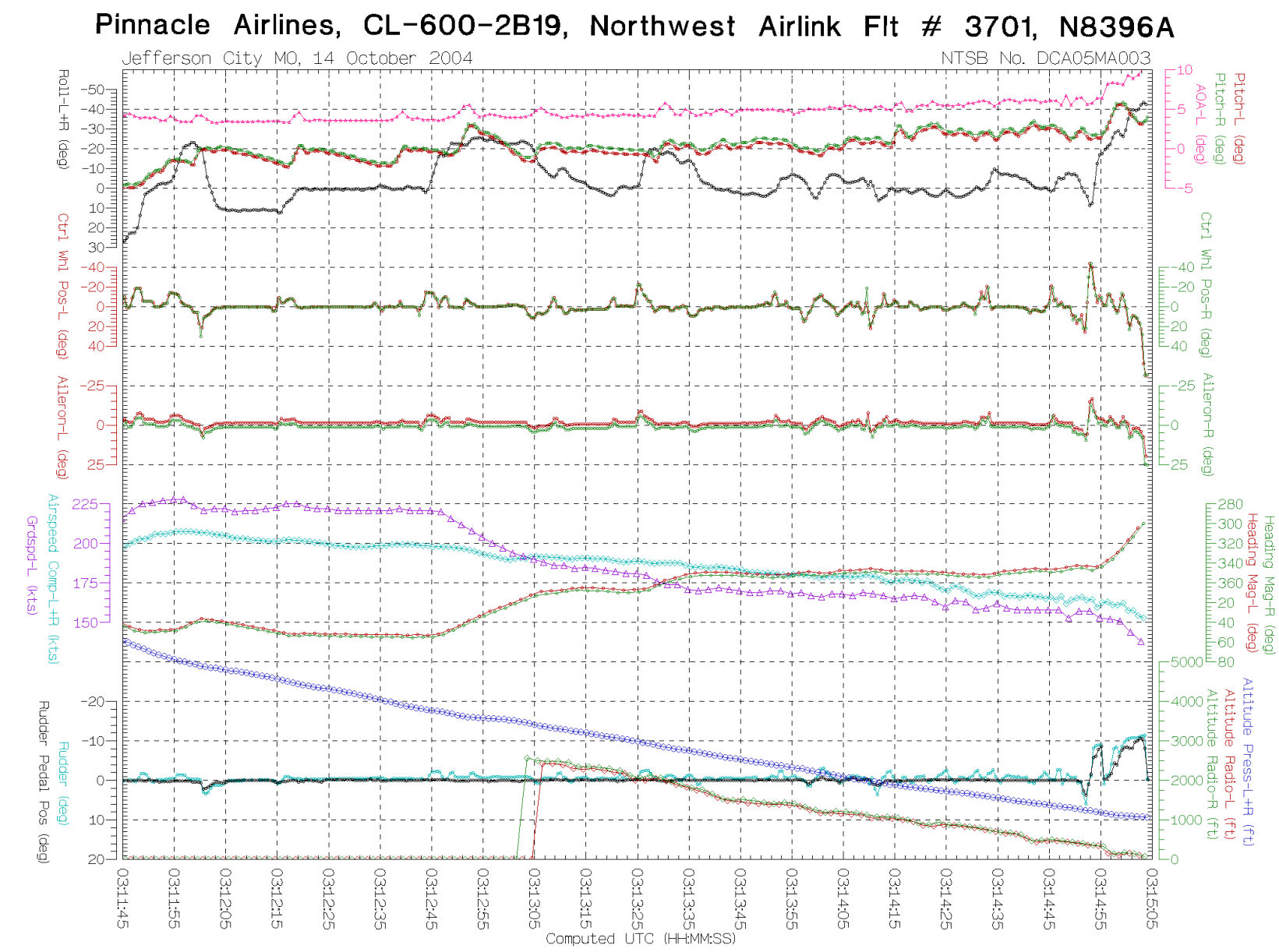
Factual Report Plot 35



Factual Report Plot 36



Factual Report Plot 37



Factual Report Plot 38

Tabular Data

A tabular listing of the data used to create Plots 1 through 38 can be found as Attachment 1 to this report. Attachment 1 is a compressed comma separated value (.CSV) format file and is only available in electronic format. The recorded GMT time parameters that were not plotted are also included in the tabular listing. All parameters plotted are included for the "Whole Flight" timeframe. The time basis for the listing is Subframe Reference Number. The conversions to Computed UTC shown in the plots are included above. The values in the listing are timed to the nearest subframe word location, one 1/128th of a second. Lines in the listing that contain only SRN have been removed to reduce the size of the file. Parameters that were plotted as combined left and right parameters (L+R) are included separately in the listing.

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Vehicle Recorder Division